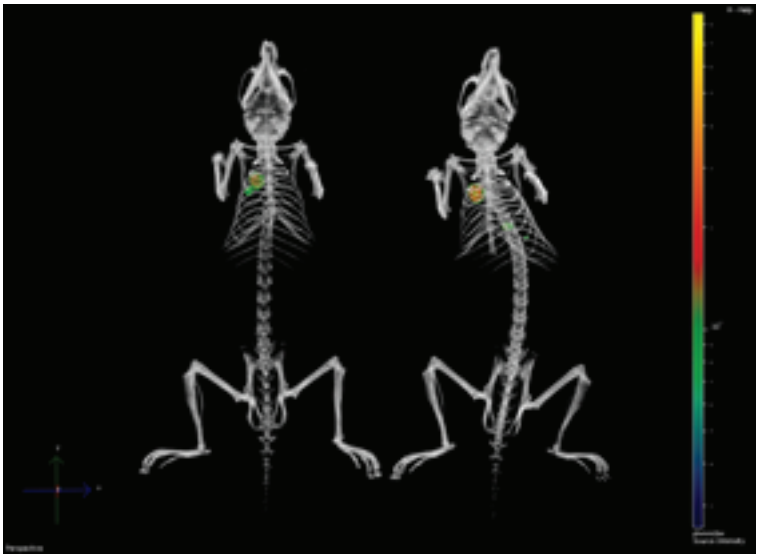
# IVIS® Spectrum CT

Computed Tomography with *in vivo* and *in vitro* Optical Imaging



# User Manual

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# 1 Welcome

*About the IVIS® Spectrum CT*

*Caliper Technical Support* on page 3

This manual explains how to operate and maintain the IVIS® Spectrum CT instrument, and provides guidelines for obtaining bioluminescent, fluorescent, or CT images. Please read this manual carefully before using the IVIS® Spectrum CT to ensure safe optimum performance and a maximum service life from the instrument.

For instructions on using the system software, please see the *Living Image® Software Manual for the IVIS® Spectrum CT* (part no. 134222).

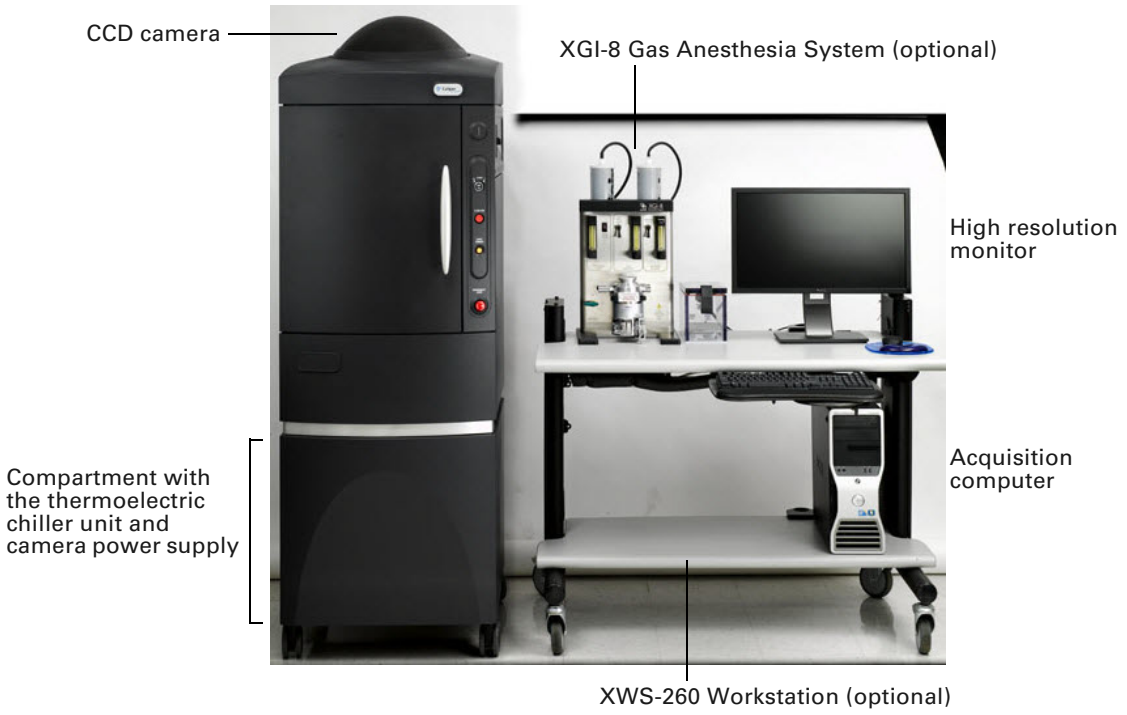
If you have questions regarding this manual or the IVIS Spectrum CT, please call Caliper technical support (see page 3).

## 1.1 About the IVIS® Spectrum CT

The IVIS Spectrum CT is an *in vivo* imaging instrument for molecular and anatomical imaging. The IVIS Spectrum CT imaging system (Figure 1.1) includes a:

- CCD camera mounted on a light-tight imaging chamber
- Camera power supply
- Thermoelectric cooling unit
- Fluorescence light source
- X-ray tube source and CMOS X-ray detector
- Windows®-based computer system for data acquisition and analysis
- Living Image® system software

**Figure 1.1** IVIS® Spectrum CT Imaging System and optional accessories


CCD camera
XGI-8 Gas Anesthesia System (optional)
High resolution monitor
Acquisition computer
Compartment with the thermoelectric chiller unit and camera power supply
XWS-260 Workstation (optional)

The sound-limiting compartment beneath the imaging chamber contains the thermoelectric cooling unit, camera power supply, and other imaging chamber functions. All components except the computer are integrated into a single, moveable chassis.

The IVIS Spectrum CT imaging capabilities include:

- Bioluminescent imaging
- Fluorescent imaging (reflectance and transmission modes)
- Low dose, ultra fast micro-CT for small animals

Together, the IVIS Spectrum CT and Living Image® system software enable:

- 3D optical tomography for fluorescence and bioluminescence
- 3D volumetric tomography of CT images
- Automatic co-registration of 3D reconstructions of luminescent or fluorescent sources (optical image data) with CT images (3D volumetric data)
- Multi-spectral fluorescence and spectral unmixing
- Cerenkov imaging for optical radiotracer imaging

## Optical Imaging

The ultra sensitive CCD camera of the IVIS Spectrum CT enables bioluminescent imaging which detects the light emitted by living cells expressing a reporter gene such as luciferase. It allows noninvasive visualization and monitoring of cellular and genetic activity within a living organism, in real time.

For fluorescence imaging, the instrument can operate in reflectance or transillumination mode. Filtered light from a broad-band lamp provides the excitation source in both modes. In the reflectance mode, light is delivered to four reflectors that are located on the ceiling of the imaging chamber. In

the transillumination mode, the excitation light is delivered to an x-y translation assembly under the stage and focused to a 2 mm diameter beam that can be directed to a particular location on the underside of the animal subject. The system includes 10 excitation and 18 emission filters that enable spectral scanning of reporters over the range from 480-850 nm.

### X-ray CT Imaging

The IVIS® Spectrum CT includes a high-speed micro-CT system for small animal X-ray imaging. It uses an X-ray source and a flat panel X-ray detector to produce high resolution 3D images of mouse skeletal structure and surrounding soft tissue. The acquisition computer incorporates a fast reconstruction method for high throughput workflows.

### 3D Tomography

The IVIS Spectrum CT imaging system uses CT images to reconstruct the surface topography. The concentration and 3D anatomical location of fluorescent sources can be computed from CT images and transillumination fluorescent images. The 3D anatomical location and strength of luminescent sources are computed from CT and luminescent image data.

## 1.2 Caliper Technical Support

For technical support, please contact Caliper at:


| | |
|---|---|
| **Telephone** | 1.877.522.2447 (US)<br>1.508.435.9500 |
| **E-mail** | tech.support@caliperls.com |
| **Fax** | 1.508.435.3439 |
| **Mail** | Caliper Life Sciences<br>US Corporate Headquarters<br>68 Elm Street<br>Hopkinton, MA 01748 |

# 2 Important Safety Instructions

*Definitions*
*Instrument Labels* on page 5
*Instructions* on page 5
*X-Ray Safety and Radiation Hazards: Regulations* on page 6
*Fluorescence Light Source Safety* on page 7
*Environmental Consideration for System Components* on page 7
*Power Considerations* on page 8
*Cleaning or Moving the System Components* on page 9
*Other Equipment or Chemicals* on page 9
*Servicing* on page 9

## 2.1 Definitions

When you see a caution, warning, or voltage symbol, pay particular attention to the safety information presented.

**CAUTION: A caution note indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury and/or mechanical damage. It is also used to alert against unsafe practices. It reminds you that all safety instructions should be read and understood before installation, operation, maintenance, or repair of this instrument.**

**WARNING! A warning alerts you to an action or condition that can potentially cause serious personal injury or loss of life. Mechanical damage may also result.**

**VOLTAGE! A voltage warning indicates high voltage or risk of electric shock.**

Observance of safety precautions will help avoid actions that could damage or adversely affect the performance of the IVIS® Spectrum CT. If the equipment is used in a manner not specified in this manual, the protection provided by the equipment may be impaired.

## 2.2 Instrument Labels

Pay careful attention to the labels on the instrument. Table 2.1 shows the safety symbols that are found on the IVIS® Spectrum CT or in this manual.

Table 2.1 Instrument labels

| Label | Description |
|---|---|
| Pinch hazard | Where located on the IVIS® Spectrum CT, the pinch hazard label indicates the location of a potential pinch point |
| High voltage | Where located on the IVIS® Spectrum CT, indicates a high voltage hazard. |
| X-ray radiation hazard | Where located on the IVIS® Spectrum CT, indicates an X-ray radiation hazard. |
| X- ray radiation hazard (Canada) | Where located on an IVIS® Spectrum CT operating in Canada, indicates an X-ray radiation hazard. |
| Read manual | Where located on the IVIS® Spectrum CT, indicates that important information about the labeled area can be found in the IVIS Spectrum CT Hardware Manual. |

## 2.3 Instructions

**WARNING! The IVIS® Spectrum CT should only be operated by personnel who have been trained in radiation safety, and the operation and safety instructions contained in this manual. Caliper also recommends that personnel who operate the equipment, or are in close proximity to the equipment, use a radiation film badge or other type of appropriate personal dosimeter.**

### Read Instructions

Read and understand all the safety and operating instructions before you install, operate, or perform maintenance on this product. Make sure that you fully understand the following safety instructions, warnings, and disclaimers before proceeding to the rest of the manual.

### Retain Instructions

Retain the safety and operating instructions for future reference.

### Follow Instructions

Follow all operating and handling instructions. Failure to follow operating or handling instructions may void any warranty covering this product.

### Heed Warnings

Abide by all warnings on the product and in the operating instructions. Failure to adhere to warnings or safety precautions may void any warranty covering this product.

## 2.4 X-Ray Safety and Radiation Hazards: Regulations

This equipment produces X-rays when energized. Before operating the equipment, read and understand the specific information in X-ray Safety & Radiation Hazards on page 15.

**WARNING! DO NOT operate the IVIS® Spectrum CT unless an X-ray safety survey has been performed within the last 12 months. For more information, please contact Caliper technical support.**

An X-ray safety survey must be performed when the instrument is installed or if abnormal mechanical shocks occurred during movement. A survey is also to be performed when the IVIS Spectrum CT has undergone any form of service in which the safety interlocks have been adjusted or any of the shielding has been removed and re-installed.

After servicing, if the safety interlocks are not operating properly or if the X-ray shielding is not properly re-installed, serious injury can result when operating the system. Conducting an X-ray safety survey is the only way to confirm proper shielding and interlock operation.

**WARNING! When performing a radiation survey of the IVIS Spectrum CT, please comply with your own laboratory radiation regulations or contact Caliper technical support for further assistance.**

Owners and operators of the IVIS Spectrum CT are responsible for complying with all regulations in the country where the equipment is operated. This includes all local, state, and federal regulations. In some states of the US, it may be necessary to register radiation sources with the governing state and/or local public health agencies before operating the instrument. Equipment registration may be required immediately or within 30 days of acquiring the equipment.

Owners and operators of the IVIS Spectrum CT are responsible for contacting the appropriate public health agencies for registration information that pertains to installation of the IVIS Spectrum CT. If you need assistance with this requirement, contact Caliper technical support. For more details and contact information, see *Safe Operating and Emergency Procedures for the Operation of the IVIS® Spectrum CT Cabinet X-ray System*. This document was provided with the pre-installation instructions.

**WARNING! A Caliper employee will conduct a radiation leakage survey and safety tests when the IVIS Spectrum CT is installed. Caliper employees are trained in radiation safety. However, check with your local radiation control authority to determine the specific radiation survey requirements at your facility. If necessary, have a qualified expert other than a Caliper employee survey the installation before operating the instrument.**

## 2.5 Fluorescence Light Source Safety

**WARNING! The IVIS Spectrum CT is equipped with a strong visible fluorescence light source. Do not stare directly into this source**

## 2.6 Environmental Consideration for System Components

### Location for the IVIS® Spectrum CT

Before installation, consider the proper environment for the IVIS Spectrum CT components. Install the equipment in an environment where:

- The temperature does not change or fluctuate widely. Choose an environment where the temperature is maintained between 18–24 °C (65–75° F).
- The humidity does not exceed 80%.
- No strong electric or magnetic fields exist.
- No vibrations are present.
- No corrosive gases are present.
- High amounts of dust are not present.
- No open flame is present.
- There is sufficient space behind the IVIS Spectrum CT equipment. A minimum space of six inches (15 cm) from the flat surface of the rear panel should be provided behind the IVIS Spectrum CT to provide unobstructed air flow and access to the main power on/off switch.
- The floor is level and structurally sound.

### Heat

The system should be situated away from heat sources such as open flames, radiators, heat registers, stoves, and other heat-generating electrical equipment.

### Water and Moisture

**VOLTAGE! Do not use the IVIS® Spectrum CT near water (for example, near a sink or wet room) due to the risk of electric shock, electrical damage, and/or system failure.**

### Laboratory Space

The IVIS Spectrum CT requires a minimum of 100 square feet (9 square meters) of laboratory space for adequate ventilation. At least of six inches of space is required behind the rear flat panel to provide unobstructed air flow. If you will be using an XGI-8 Gas Anesthesia System or other anesthesia system, refer to the anesthesia system manual for additional ventilation requirements to avoid exposure to waste anesthesia gases.

Allocate an area that is at least 36 inches (91.4 cm) wide and 51 inches (129.5 cm) deep for the instrument to allow the door to be fully opened and provide the recommended air space behind the instrument.

An additional area that is 48 inches (121.9 cm) wide should be available, preferably to the right of the instrument, to accommodate a table or cart to hold the computer and provide a work surface.

## 2.7 Power Considerations

### Power Sources

The IVIS Spectrum CT is configured for the voltage requirements of the installation locality that was specified at the time of order. The set voltage is marked on the outside of the product itself, and should only be powered by that voltage. If the system is moved to another area, check to make sure that the same voltage requirements exist at the new location.

An IVIS® Spectrum CT that operates on 120VAC requires a dedicated 20 Amp circuit that is not shared with other loads except the computer and the optional XGI-8 Gas Anesthesia System. Ensure that all equipment is plugged into a properly grounded AC supply.

The computer should share the same circuit to avoid ground loops. Never use auxiliary power outlets on other equipment to supply the IVIS Spectrum CT. Since the system contains internal surge protection, it must be powered directly from the main electrical supply wall socket. Use the surge protector provided by Caliper for the computer and other accessories.

An IVIS Spectrum CT configured for 230 VAC requires a dedicated minimum 10 Amp circuit subject to the same conditions described above. For more details on the operating requirements, see *Electrical Power Requirements* on page 25.

**VOLTAGE! The IVIS Spectrum CT can operate at multiple voltages (100, 120, 220, 240 VAC); however, you are not permitted to change the input voltage to any of the system components. The instrument should only be powered by the set voltage which is marked on the outside of the product itself. Several internal modifications are required for voltage change. If the operating voltage must be changed, contact Caliper technical support (see page 3).**

### Power Cord Protection

Power supply cords should be routed so that they are unlikely to be walked on or pinched by items placed upon or against them. Pay close attention to receptacles and to the points of connection between cords and equipment.

If it becomes necessary to replace the power cord, the replacement power cord set should be adequately rated for the voltage and current, and suitably selected and certified as required in the country of end installation.

A separate surge protector is provided for the computer and other accessory equipment. Facilities should be adequately wired according to local building codes.

### Power Outages

If the IVIS Spectrum CT experiences a loss of supply power, turn off the power switch for all components and do not restart the system until reliable power has been restored. For more details on how to restart the system, see *Restarting the System After a Power Outage*, page 43.

### Overloading

**WARNING! Do not overload wall outlets, extension cords, or integral convenience receptacles as this can result in a risk of fire or electric shock. For electrical power requirements, see page 25.**

## 2.8 Cleaning or Moving the System Components

### Cleaning/Liquid Entry

**VOLTAGE! Do not use liquid or aerosol cleaners and never spill liquid of any kind on any of the IVIS Spectrum CT components. Sprays and liquids that come into contact with the IVIS Spectrum CT may result in damage to the system or electrocution. For more details on proper care of the system, see *Cleaning the IVIS® Spectrum CT*, page 58.**

### Moving the IVIS Spectrum CT

The IVIS Spectrum CT is a sensitive, scientific instrument and should be moved with care. Pay particular attention when rolling the instrument on its casters to avoid toppling the equipment.

The total height of the instrument is 77 inches (195.6 cm). If necessary, the plastic dome can be removed for easier passage through doorways. For more details on removing the dome, see page 65.

If you have any questions about moving the instrument, contact Caliper technical support.

## 2.9 Other Equipment or Chemicals

The use of any equipment other than that recommended by this manual has not been evaluated for safety and, therefore, is the sole responsibility of the user.

No chemicals are required for the operation of the IVIS® Spectrum CT. Other user-supplied chemicals or materials may be required as part of your specific biological testing procedures.

Do not modify the IVIS Spectrum CT in ANY manner by making any kind of hole or aperture in the instrument or removing any component of the radiation shielding.

## 2.10 Servicing

Refer all servicing to Caliper technical support. If the instrument is damaged and requires service, unplug the instrument from the outlet and contact Caliper technical support. Servicing by anyone other than those authorized by Caliper voids any warranty covering the instrument.

# 3 Warnings

*Electrical Safety*

*X-ray Safety* on page 10

*Mechanical Safety* on page 11

*Chemical and Biological Safety* on page 11

*Eye Safety and Burn Hazard* on page 12

*The IVIS Spectrum CT is equipped with a fluorescence light source module and connecting fiber optic cables that are capable of producing intense light that could be damaging to the eyes. The protection means provided by the system prevents access or exposure to the fluorescent light.Panels, Covers, and Modules* on page 12

## 3.1 Electrical Safety

**WARNING! DO NOT attempt to service the IVIS® Spectrum CT yourself. Contact Caliper technical support for electrical service needs. Although there are no voltages in excess of 45V inside the imaging chamber, local line voltages can be present inside the electronics cabinets.**

**CAUTION: If cleaning is necessary, wipe the exterior surfaces of the IVIS Spectrum CT with a soft, damp cloth only. Do not allow fluids of any kind to enter the system interior under any circumstances. For more details on cleaning the system, see page 58.**

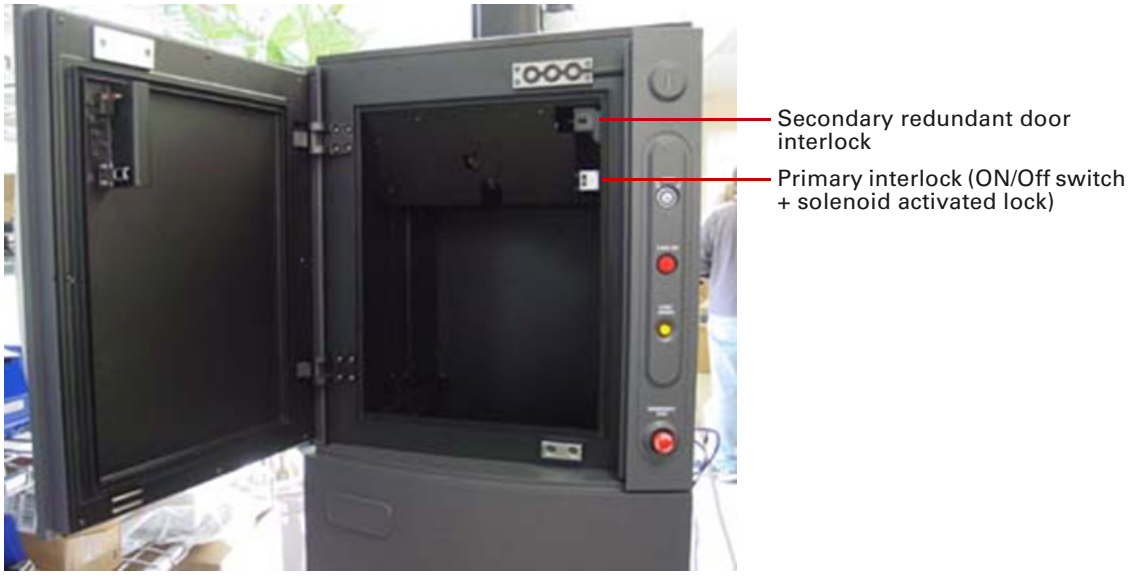
## 3.2 X-ray Safety

**WARNING! This equipment produces X-rays when energized**

**WARNING! The IVIS Spectrum CT should be operated only by personnel who have been trained in radiation safety, and the operation and safety instructions contained in this manual. Caliper also recommends that personnel who operate the equipment, or are close proximity to the equipment, use a radiation film badge or other type of appropriate personal dosimeter.**

The IVIS Spectrum CT has multiple safety interlocks that prevent X-ray generation when the door is open (Figure 3.1). The primary interlock switch prevents any generation of X-rays unless the door is completely closed. A secondary redundant door interlock prevents X-ray generation when the instrument door is opened. See *Safety Interlocks* on page 21 for more details on the primary and secondary safety interlocks.

**Figure 3.1** IVIS Spectrum CT safety interlocks




## 3.3 Mechanical Safety

The IVIS® Spectrum CT has many internal motorized components that can only move when the door is closed and locked. The imaging platform moves frequently during routine use; keep loose objects away from the edges of the platform where they could become jammed.

**CAUTION: DO NOT defeat any of the instrument safety interlocks. Do not place anything under the imaging platform.**

The imaging platform cannot move unless the door is closed and locked. If the platform moves when the door is unlocked, shut down the system and contact Caliper technical support.

The IVIS Spectrum CT contains several delicate optical and mechanical components. Do not touch these components and avoid using sprays or other contaminates that may damage lenses or other optical-mechanical components.

## 3.4 Chemical and Biological Safety

Normal operation may involve the use of samples that are pathogenic, toxic, or radioactive. It is your responsibility to ensure that all necessary safety precautions are taken before such materials are used.

Dispose of all waste materials according to appropriate environmental health and safety guidelines.

It is your responsibility to decontaminate the IVIS Spectrum CT before requesting service by Caliper technical support. Ask your laboratory safety officer to advise you about the level of containment required for your application and the proper decontamination or sterilization procedures.

Handle all infectious samples according to good laboratory procedures and methods to prevent the spread of disease.

## 3.5 Eye Safety and Burn Hazard

The IVIS Spectrum CT is equipped with a fluorescence light source module and connecting fiber optic cables that are capable of producing intense light that could be damaging to the eyes. The protection means provided by the system prevents access or exposure to the fluorescent light.Panels, Covers, and Modules

Aside from the imaging chamber door, the filter wheel access panel and the lower rear cart panel are the only user removable panels. The lower rear cart panel allows access to the chiller for coolant filling. There are no user serviceable components in the electronics cabinets of the IVIS Spectrum CT. Do not remove the electronics cabinet covers from the instrument unless instructed by and under the supervision of Caliper technical support.

Do not modify the IVIS Spectrum CT in ANY manner by making any kind of hole or aperture in the instrument. Do not remove any component that is part of the radiation shielding. In certain situations, the Emission Filter Wheel Access Panel may be removed (see page 60).

# 4 Legal Notices

*Limited Warranty*

*Patents* on page 14

*Trademarks* on page 14

## 4.1 Limited Warranty

Caliper Life Sciences, Inc. ("Caliper") provides the following limited warranty for each new IVIS® Spectrum CT ("System") as follows ("Limited Warranty"):

**i.** This Limited Warranty for the System extends to the original purchaser ("Customer") for a period of one (1) year following installation of the System, and is not assignable or transferable to any successor.

**ii.** During the Limited Warranty, Caliper will repair or replace, at Caliper's sole option, any defective parts if such repair or replacement is needed because of System malfunction or failure to conform to published specifications during normal usage in accordance with the instructions in this manual. Repairs and replacements under the Limited Warranty will be made at Caliper's expense. Caliper's limit of liability under the Limited Warranty shall be the purchase price of the Imaging System. Caliper shall not be liable for any other losses or damages. These remedies are the Customer's exclusive remedies for breach of this Limited Warranty.

**iii.** No coverage or benefits shall be provided under this Limited Warranty if any of the following conditions apply:

**a)** The System has been subjected to unauthorized modifications (e.g. unauthorized installation of hardware or software), unauthorized repair or servicing, misuse, neglect, abuse, accident, alteration, any use inconsistent with or in contradiction to the instructions in this manual, or other acts which are not the fault of Caliper.

**b)** Caliper was not advised in writing by the Customer of the alleged defect or malfunction of the System within the earlier to occur of ten (10) days after the expiration of the Limited Warranty period, or 15 days after becoming aware of the defect or malfunction.

**c)** If Customer moves the System from its installed location to another location without Caliper's technical assistance, then any damage to the System due to such movement shall not be covered under the initial warranty or any extended warranty, and Licensee shall pay Caliper's standard service rates for repair of such damage.

**iv.** If a problem develops during the Limited Warranty, the Customer shall contact Caliper technical support for assistance.

**v.** THE FOREGOING LIMITED WARRANTY IS THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. CALIPER SHALL NOT BE LIABLE FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO LOSS OF ANTICIPATED BENEFITS OR PROFITS, LOSS OF SAVINGS OR REVENUE, PUNITIVE DAMAGES, LOSS OF USE OF THE SYSTEM OR ANY ASSOCIATED EQUIPMENT, COST OF CAPITAL, COST OF ANY SUBSTITUTE EQUIPMENT OR FACILITIES, DOWNTIME, THE CLAIMS OF ANY THIRD PARTIES, INCLUDING CUSTOMERS, AND INJURY TO PROPERTY, RESULTING FROM THE PURCHASE OR USE OF THE SYSTEM OR ARISING FROM BREACH OF THE WARRANTY, BREACH OF CONTRACT, NEGLIGENCE, STRICT TORT, OR ANY OTHER LEGAL OR EQUITABLE THEORY, EVEN IF CALIPER KNEW OF THE LIKELIHOOD OF SUCH

DAMAGES. CALIPER SHALL NOT BE LIABLE FOR DELAY IN RENDERING SERVICE UNDER THE LIMITED WARRANTY, OR LOSS OF USE DURING THE PERIOD THAT THE SYSTEM IS BEING REPAIRED.

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## 4.2 Patents

The detection and imaging of light originating within mammals is the subject of several issued patents and pending patent applications in the United States and around the world, including U.S. Patent Numbers 5,6200,135, 6,217,847, 6,649,143, 6,890,515, and European Patent Commission Number EP0861093, for which Xenogen Corporation is the exclusive licensor. The use of an IVIS® Imaging System for such applications requires a sublicense from Xenogen Corporation.

In addition, many of the hardware and software components of the Imaging System are the subject of various issued patents and pending patent applications owned by Xenogen, including: United States Patent Number 6,614,452 (Graphical User Interface for In Vivo Imaging) and 6,775,567 (Improved Imaging Apparatus); and United States Patent Applications 09/905668 (Multi-view Imaging Systems), 10/606976 (Method and Apparatus for 3-D Reconstruction of Light Emitting Sources), 10/151463 (Method and Apparatus for Determining Target Depth, Brightness, and Size Within a Body Region), 10/189886 (Fluorescence illumination assembly for an imaging apparatus), and 10/068573 (Light calibration device for use in low level light imaging systems).

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# 5 X-ray Safety and Radiation Hazards

*Introduction*

*Radiation Theory and X-ray Generation* on page 16

*Biological Effects of Radiation* on page 17

*IVIS Spectrum CT Safety Systems* on page 19

*Regulatory Compliance and Laboratory X-ray Safety Procedures* on page 23

## 5.1 Introduction

The IVIS® Spectrum CT produces X-ray radiation. This radiation is confined to the interior of the imaging chamber. Spectrum CT will only produce X-rays when the CT function has been armed and energized. The instrument may also be operated in standard bioluminescent or fluorescent mode without X-ray generation.

The IVIS Spectrum CT is defined by most regulatory agencies as a "Cabinet X-Ray System." A cabinet system is one that produces little or no X-ray exposure to the user and is safe to operate with the user in close proximity. Caliper certifies that the IVIS Spectrum CT produces not more than 0.5 millirem per hour at a distance of 5 cm from the instrument surface. The instrument is also certified to meet all international exposure requirements (typically 0.1 millirem per hour) and other regulations that apply to the user's location. The IVIS Spectrum CT meets all US (FDA) regulations regarding a cabinet X-ray system. For information on international limits for X-ray doses, see page 18.

### Product Documentation

Users will receive pre-installation information to help prepare the laboratory for installation of the IVIS Spectrum CT and any accessories purchased with it.

Table 5.1 lists the documents provided in PDF format on CD with the instrument.

Table 5.1 Documents provided with the IVIS Spectrum CT Imaging System

| Document Name | Description | Part No. |
|---|---|---|
| *Safe Operating and Emergency Procedures for the Operation of the Spectrum CT Cabinet X-ray System* | Explains safe operating and emergency procedures for the IVIS Spectrum CT. Provides a list of contacts for radiation protection in the United States and Canada. | 133919 |
| *IVIS® Spectrum CT Hardware Manual* | Provides information about safe operation of the IVIS Spectrum CT, system components, care and maintenance of the system, and spare parts. | 133577 |
| *Living Image® Software Manual for the IVIS® Spectrum CT* | Provides instructions for image acquisition on the IVIS Spectrum CT and image analysis using the Living Image software. | 134222 |

## 5.2 Radiation Theory and X-ray Generation

Radiation is everywhere. Our bodies are continuously bathed in radiation in the form of sunlight, radio, and television waves as well as radiation produced by the earth's natural background radiation that is produced by radioactivity and cosmic rays. Radiation is distinguished by its ability to ionize chemical bonds and is characterized as either ionizing or non-ionizing.

Ionizing radiation has the ability to affect biological organisms including human beings by interacting with cellular chemistry. Radiation such as sunlight, is usually considered non-ionizing radiation, although there is some overlap when discussing ultra-violet radiation.

X-rays are a form of electromagnetic radiation similar to light; however, X-rays have much shorter wavelengths. X-rays have wavelengths from 10 to 0.01 nanometers, whereas visible light ranges from 700 to 400 nanometers. Non-visible ultraviolet light fills the gap between visible light and X-rays with wavelengths ranging from 400 to 10 nanometers. Non-visible ultraviolet light is also considered an ionizing radiation, but it does not possess the penetrating capability of X-rays. In summary, X-ray radiation is an ionizing form of electromagnetic radiation that has sufficient energy to break chemical bonds.

The IVIS® Spectrum CT uses an X-ray generating tube to produce ionizing radiation, which if left un-shielded could be harmful to people or animals. The IVIS Spectrum CT instrument includes shields that confine the X-rays within the imaging chamber. Consequently, operation of the IVIS Spectrum CT does not expose the operator to unsafe X-ray exposure.

At least two complete radiation surveys are conducted to verify the instrument design, ensure proper manufacturing and installation, and make certain that there is no leakage from the instrument that exceeds the US and international regulations.

### X-rays: Ionizing Radiation

As noted above, X-rays are classified as ionizing radiation that is capable of removing or rearranging the electronic bonds of chemical compounds. For this reason they are considered potentially hazardous to living organisms. X-rays can also interact with matter by scattering off of atoms in new directions. Therefore, the IVIS Spectrum CT incorporates shielding that completely blocks scattered radiation in all possible directions, including the primary beam direction.

Ionizing radiation can also be produced by radioactive materials. However, since the IVIS Spectrum CT contains no radioactive materials there is no possibility of transferring a radioactive contaminate from the instrument to the laboratory during a procedure such as cleaning the imaging chamber.

### X-rays: Penetrating Radiation

The ability of X-rays to penetrate matter makes them useful in applications such as medical imaging and industrial inspection. The IVIS Spectrum CT uses an X-ray tube source with the minimum energy required to generate X-rays that penetrate and image mice. Even though X-rays are able to penetrate matter such as tissue or plastic, they are not able to make matter radioactive.

### How X-rays are Generated

The IVIS Spectrum CT is a computed tomography (CT) imaging system that consists of a fixed X-ray source which produces a cone beam of X-rays. The shelf consists of the main platform and a rotating animal stage. For CT imaging the platform moves down into the bottom of the instrument. During CT Imaging the animal stage rotates about the vertical axis while the fixed horizontal beam

of X-rays penetrates the animal. The X-ray source is in the behind the rear of the imaging chamber and the X-ray detector is in the front.

The X-ray source is an X-ray tube (see page 17 for more details on the tube characteristics); its basic function is to generate X-rays of a maximum energy of 50,000 electron volts. The X-rays are produced by the collision of high energy electrons with a tungsten metal target in a vacuum tube. When high voltage is applied between a heated cathode and the tungsten anode, electrons are stripped from the cathode and are accelerated into the anode. The collision of those electrons produces X-rays.

There are two atomic processes capable of producing X-rays from these collisions. One process, known as *bremsstrahlung* (from the German "braking radiation"), generates X-rays by the rapid deceleration of the high energy electrons as they interact with the repulsive electron field of the tungsten target metal.

The second X-ray generating process results from the high energy free electrons interaction with the atomic orbitals of the target metal. The Spectrum CT X-ray tube generates X-rays using both of these processes. The tube generates a spectrum of X-rays from approximately 10keV to the maximum of 50keV.

Two thin filters, one made of copper and the other of aluminum, can be placed in the X-ray beam to reduce unusable low-energy radiation. A thick filter made from tungsten is placed in front of the beam during source warm-up in order limit the animal's X-ray exposure.

### IVIS® Spectrum CT X-ray Source Tube

The X-ray generating tube is located behind an interlocked panel on the rear of the IVIS Spectrum CT. The tube is neither accessible nor serviceable by the user. The X-ray tube, high voltage power supply and other electronic circuits are located within the interlocked shielded cabinet. Only Caliper Field Service personnel are allowed to remove the access panel as it requires the use of a special tool to remove the tamper proof screws.

**NOTE:** The only user-accessible door and panels are the imaging chamber door, the filter access panel (see page 60), and the lower rear cart panel that provides access to the thermoelectric chiller (see page 62). There are no other panels that can be removed or opened by the user.

The tube is rated at 50kV high voltage potential with a maximum beam current of 1milliAmp. Total power is 50.0 watts. The X-ray window is 0.13 mm (0.005 inches) thick beryllium and the X-ray target is tungsten. The X-ray tube controls, including ON/OFF and beam power settings, are carried out by Spectrum CT software commands which limit the X-ray tube voltage to 50kV maximum.

## 5.3 Biological Effects of Radiation

X-rays are a form of electromagnetic radiation that has enough penetrating energy to ionize atoms within a cell. Ionization occurs when an X-ray photon interacts with an orbital electron and transfers energy to it, causing the electron to be ejected from the atom. Such ionizations may disrupt molecules such as DNA. The DNA molecule can be broken by the radiation and the cell can be severely damaged resulting in cell death. With enough cell death, tissue and organs can be damaged. Injury to a living organism can also occur in indirect ways such as the creation of free radicals or other ions. The deleterious effects of radiation exposure are classified into two categories: deterministic effects and stochastic effects.

## Deterministic Effects

Deterministic effects are those effects in which a clear causal connection can be made between the exposure to radiation and the effect. Deterministic effects are the result of cell killing and tissue damage. This effect is dose related—a radiation dose greater than a certain threshold must occur which produces enough cell death to result in tissue damage. After the dose threshold is exceeded, the severity of the effect is increased by the amount of the dose.

Examples of deterministic effects of radiation due to overexposure of X-rays include: skin changes (reddening, pigmentation changes, blistering, and ulceration), cataract formation, and fetal abnormalities due to exposure *in utero*.

The deterministic effects of radiation can be classified as either acute or delayed. An acute effect such as skin reddening occurs soon after overexposure to radiation whereas a delayed affect such as cataracts may take some time, even years, to develop. For deterministic effects there is a clear connection between the individual exposure to radiation and the biological effect. The biological effect requires a minimum threshold dose, and the severity of the effect increases with increasing dose.

## Stochastic Effects

Stochastic effects are biological effects that have a statistical probability of occurring based on the radiation dose. Unlike deterministic effects, stochastic effects have no dose threshold. Even for low radiation doses there is a small probability of a biological effect occurring. The severity of the stochastic biological effect can be unrelated to the magnitude of the dose, but the probability of occurrence increases with increased dose or length of exposure.

Stochastic effects cannot be linked to a specific radiation exposure with certainty. For example, stochastic effects such as cancer can also occur in individuals who have not been exposed to radiation above background levels, therefore it is not possible to determine that the cancer resulted from any specific exposure.

## X-ray Dose Limits

The IVIS® Spectrum CT has been tested at maximum operating conditions and Caliper has determined that the local X-ray dose rate at a distance of 5 cm from the surface of the equipment is less than 1.0 µSv/h.

Caliper declares that the IVIS® Spectrum CT system conforms to:

- 1996/29/Euratom Directive (Dose rate of 1 µSv/h at 10 cm from any accessible surface under normal operating conditions)
- US CFR21 Part 1020.40 Regulation (Dose rate of 0.5mrem/h at 5cm outside of the external surface under maximum operating conditions) in accordance with the following standard:

  IEC 61010-1:2001 Standard (Dose limit of 1 µSv/h at 10 cm from the surface of the equipment under maximum operating conditions)

Caliper certifies that the IVIS Spectrum CT has achieved the objectives of the:

- ICRP 60 recommendations of annual public dose limit of 100mrem
- ICRP 103 recommendations of annual public dose limit of 100mrem
- US OSHA workplace annual public dose limits of 100mrem and other international public safety standards and regulations.

It is unlikely that properly trained individual using the IVIS Spectrum CT will receive an annual dose that exceeds these public dose limit levels.

## 5.4 IVIS Spectrum CT Safety Systems

The IVIS® Spectrum CT has many different safety features that are intended to keep the operator safe from radiation exposure. Some of these features are discussed in this manual as well as the *Safe Operating and Emergency Procedures for the operation of the Spectrum CT Cabinet X-ray System* (part no. 133919),

**CAUTION: To prevent the development of unsafe operating conditions in the instrument, do not tamper with the instrument and follow the maintenance procedures in Chapter 10 on page 57.**

### Radiation Shielding

The IVIS Spectrum CT is considered a cabinet X-ray system because all of the radiation is confined to the inside of the metal structure. This is accomplished by using steel of a sufficient thickness to block X-rays of the energies produced by the X-ray source tube described on page 17. Some cabinet parts incorporate additional shielding to prevent leakage. There are no ports, apertures, or other openings through which any part of the human body can be placed when X-rays are being generated.

**WARNING! Do not modify or remove any of the steel shielding in the IVIS Spectrum CT. If the instrument door does not completely close, do not operate the IVIS Spectrum CT and contact Caliper technical support.**

### The IVIS Spectrum CT Control Panel

The IVIS Spectrum CT is controlled primarily by software through a proprietary Caliper program. Some control functions are located on the main console electronics panel in compliance with requirements for cabinet X-ray systems. However, the controls and indicators on the main module are "enablers" only. The initiation and termination of an X-ray imaging session is controlled from the computer through the Spectrum CT software. Figure 1.1 shows the IVIS Spectrum CT and its main console electronics panel.

X-rays can only be generated when the main console is armed for X-ray mode. This means that the Emergency Stop switch is in the OUT position, the key switch is in the ON position, and all safety interlocks are working.

X-rays can be terminated from the computer as the result of ordinary operation at the programmed end of image acquisition or from the computer control panel. X-ray generation can be aborted by pushing the Emergency Stop button (IN) or by turning OFF the key switch.

**NOTE:** The Emergency Stop button will turn off power to the entire system.

A redundant interlock, as prescribed by the United States FDA, completely disconnects the power to the X-ray source if the door is opened to a gap of 5 mm (0.2 inches). The X-ray leakage seal of the door incorporates an overlap edge design which prevents radiation escape through this gap. Also, during X-ray operation, a solenoid-operated door lock prevents opening of the door. This door lock remains engaged for four seconds after X-ray power has been turned off. This ensures that the door

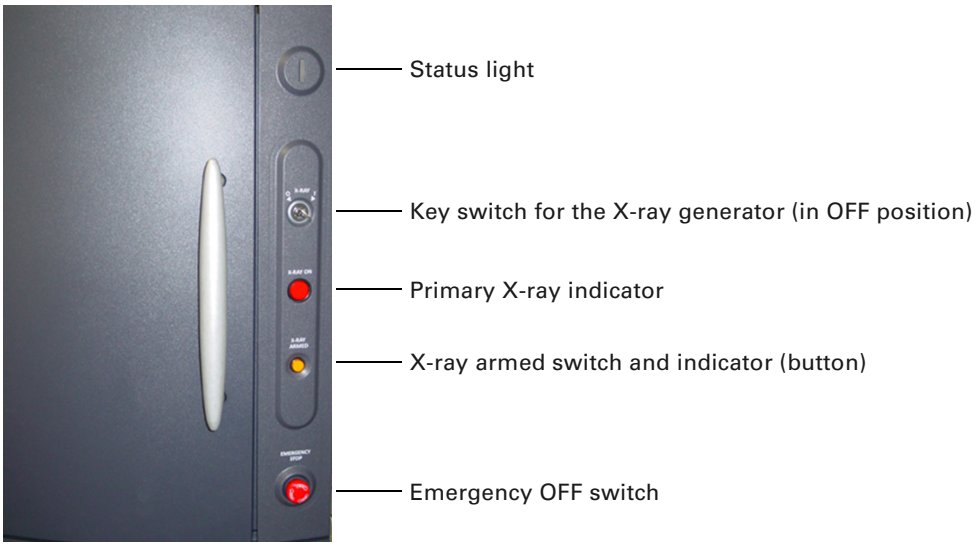
can only open after the X-ray source voltage is turned off and the radiation field has completely collapsed.

## Requirements for Turning on X-rays

X-rays can be generated when the following conditions are met.

1. The Emergency Stop button is in the ON (out) position (Figure 5.1).
2. The keyed on/off switch is in the ON position. This keyed switch is the main ON/OFF enabling switch on the IVIS® Spectrum CT console control panel.
3. The X-ray Armed push button is on and lighted.
4. The instrument door is closed and locked (engages the primary and redundant safety interlocks).
5. The filter wheel access panel is attached.
6. X-rays are activated from the Living Image® software.

**Figure 5.1** IVIS® Spectrum CT console control panel


Status light
Key switch for the X-ray generator (in OFF position)
Primary X-ray indicator
X-ray armed switch and indicator (button)
Emergency OFF switch

### X-ray ON Indicators

The IVIS® Spectrum CT is equipped with three indicators that show the status of X-ray generation (Table 5.2).

Table 5.2 X-ray ON indicators

| Indicator | Description |
|---|---|
| | The X-ray indicator light on the main console control panel. This indicator is independent of the other two indicators. If it malfunctions, the remaining two indicators are operational. |
| | The X-ray indicator in the IVIS Acquisition Control Panel in the Living Image® software. |
| | A light under the translucent dome at the top of the instrument which is visible from 360 degrees. This figure shows the light with the dome removed. This light illuminates the entire dome when X-rays are being generated |

## Safety Interlocks

**WARNING! Never defeat the primary and the redundant safety interlocks. Defeating the safety interlocks could result in serious injury of death.**

The IVIS Spectrum CT has multiple safety interlocks that prevent X-ray generation when the door is open. The primary interlock switch is activated as soon as you close the door. The primary interlock switch is an ON/OFF switch that is combined with a solenoid activated lock. It prevents any generation of X-rays unless the door is completely closed.

An actuator key is inserted into the solenoid-activated ON/OFF switch when the instrument door is closed. This completes the electrical circuit for the X-ray tube. After the X-ray circuit is turned ON, the actuator key is captured by a solenoid lock which prevents the door from opening while X-rays are being generated.

A secondary redundant door interlock prevents X-ray generation when the instrument door is opened.

**Figure 5.2** Primary and secondary safety interlock switches on the imaging chamber door

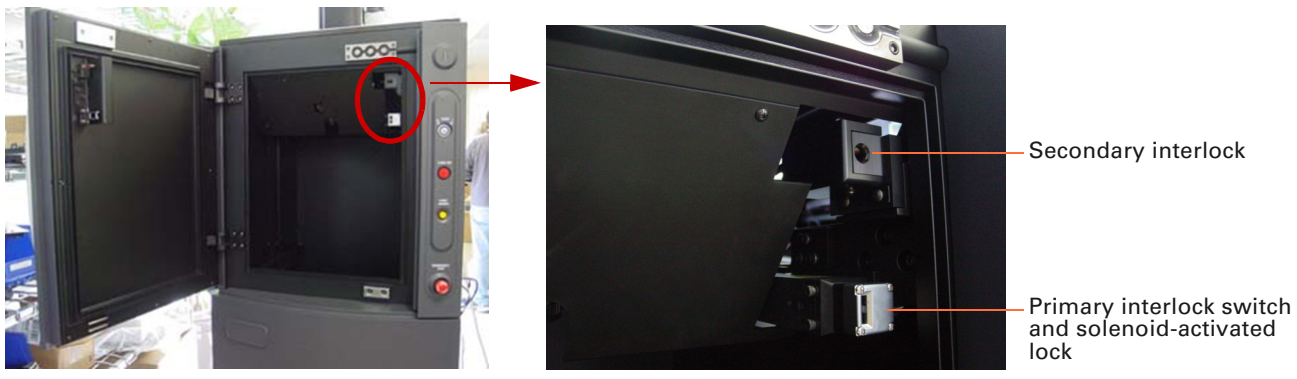
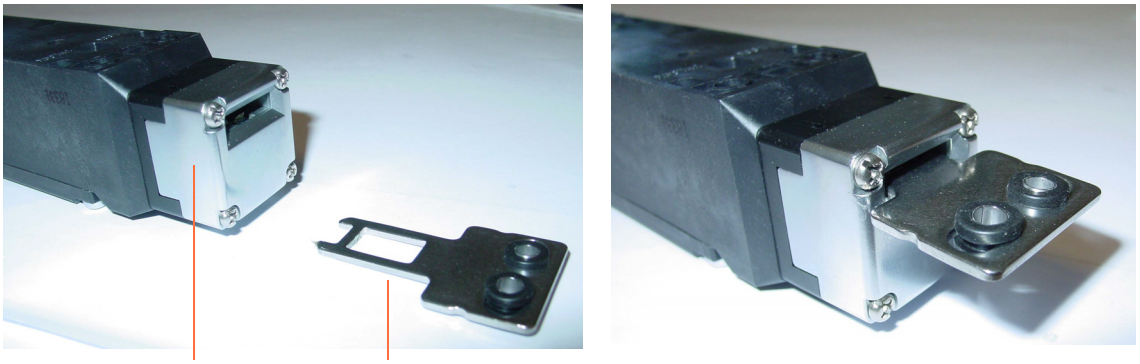


Figure 5.3 shows the primary solenoid lock with its activation key engaged and disengaged to demonstrate its principal of operation. When the solenoid is activated by electrical power, the key is retained by a mechanical lock. The solenoid lock also acts as the primary switch which completes the circuit that allows imaging to begin.

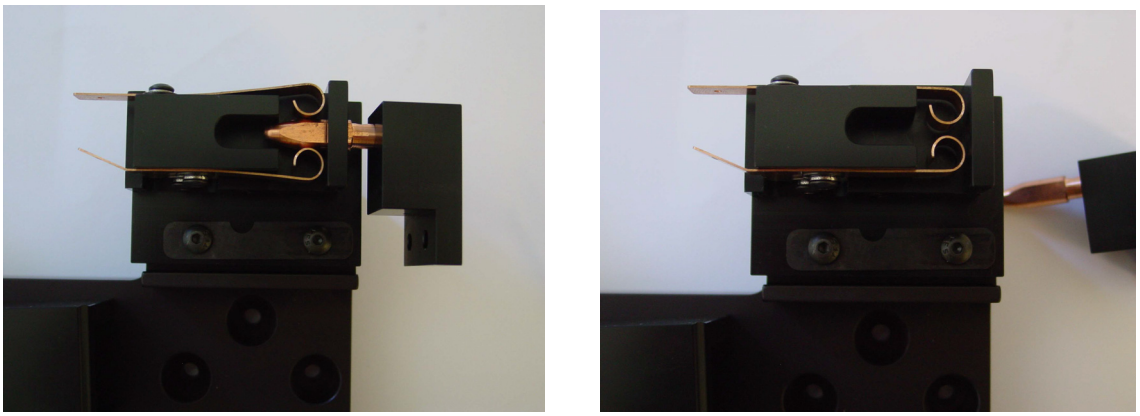
**Figure 5.3** Primary door interlock and activation key




A second redundant door interlock prevents X-ray generation by physically removing part of the X-ray electrical circuit when the imaging chamber door is opened.

Figure 5.4 demonstrates the principal of operation for the redundant interlock. A copper rod is permanently mounted on the door. When the door is opened, part of the electrical circuit is removed from the X-ray generating circuit and contact is lost between the two flexible contacts in the switch body. This switch is sometimes referred to as a CDRH switch and meets US FDA requirements as well as some other international regulations.

**Figure 5.4** Second redundant safety interlock switch



# 5.5 Regulatory Compliance and Laboratory X-ray Safety Procedures

Aside from what Caliper has done to make a safe system, there are some things that are required of the user to ensure that the instrument operates safely and within legal authority.

## Contact the State or Provincial Radiation Protection Authority

You must contact your state or provincial radiation protection authority before operating the IVIS® Spectrum CT. Contact information is provided in *Safe Operating and Emergency Procedures for the operation of the Spectrum CT Cabinet X-ray System* (PN 133919). This document was provided at the time of ordering; it is also included on the IVIS® Spectrum CT Hardware Manual CD as well as the CD governing international documentation. Chapter 11 also provides contact information for United States radiation authorities (page 69) and Canadian Provincial radiation authorities (page 78).

In most cases, you will be required to register the IVIS Spectrum CT with the state or provincial radiation protection authority. This registration may require periodic renewal.

## Study Documentation

Before operating the IVIS Spectrum CT, you should read and understand this manual as well as the software manuals provided with the instrument. Pay particular attention to the safety procedures described in *Safe Operating and Emergency Procedures for the operation of the Spectrum CT Cabinet X-ray System* (PN 133919). This document can help you prepare a radiation safety plan which is described in the next section.

## Create a Radiation Safety Plan

Your institution may require that you have a written radiation safety plan. Such plan may already exist at your institution and may also be a requirement of your registration with the state or provincial radiation protection authority. Here are some key points of a radiation safety plan:

- Persons using the IVIS Spectrum CT must read all documentation supplied with the instrument.
- Permit only trained and authorized individuals to operate the Spectrum CT. Wear personal radiation monitors if required. Caliper recommends wearing them even if they are not required.
- Designate a "master key" person who controls access to the Spectrum CT.
- If required, install the instrument in a controlled access or restricted access room.
- Post any required "Caution X-ray" signs required by your regulating authority.
- Designate a person responsible for ensuring that the safety and maintenance procedures specified in this manual are performed.
- Frequently verify that all safety procedures are followed, the IVIS Spectrum CT has not been modified, and no safety interlocks have been disabled.
- Follow all guidance supplied by your local, state, or provincial radiation protection authority. If that guidance conflicts with the Caliper supplied information, either written or spoken, contact Caliper technical support so that the conflicts can be resolved.
- Keep records of X-ray surveys, instrument repairs, or other data required by the radiation protection authority or your institution. Keep registration certificates, compliance or safety audit reports, instrument inspections, training records, and the list of authorized users. Keep records of any accident or investigation reports, or worker complaints.

## Create a Training Plan

If your radiation protection authority or your institution requires a radiation training plan, you may find the following suggestions helpful.

- Use the documentation supplied with IVIS® Spectrum CT for specific training instructions for the instrument. Use supplemental information for more in depth coverage of topics such as radiation safety.
- Identify radiation hazards associated with the use of the IVIS Spectrum CT.
- Characteristics of radiation. Units of dose.
- Discuss the various warning and safety devices incorporated in the IVIS Spectrum CT. Point out the importance of having them in working condition.
- Proper operating procedures for the equipment.
- If the trainee will be conducting radiation surveys, discuss the operation, calibration, and limitations of radiation survey instruments.
- Proper survey techniques (if surveys are conducted by non-Caliper personnel).
- Methods of controlling radiation dose, such as time, distance and shielding. Principles and practice of maintaining X-ray exposure to as Low As Reasonably Achievable (ALARA).
- Personal monitoring.
- Symptoms of acute localized exposure and proper reporting procedure for an actual or suspected exposure.
- Applicable state, provincial, local, and institutional regulation or policies.

# 6 Specifications

*Electrical Power Requirements*
*CCD Camera (Optical Imaging)*
*Optics* on page 26
*X-ray Source* on page 26
*X-ray Detector* on page 26
*Fluorescent Imaging Components* on page 27
*Environmental Temperature and Humidity* on page 27
*Weight and Dimensions* on page 27

## 6.1 Electrical Power Requirements

Table 6.1 Electrical power requirements

| Requirement | Specification |
|---|---|
| Nominal voltage required (main console) | 100-120VAC 50/60Hz 12A or 220-240VAC 50/60Hz 6A<br>(Overvoltage Category II for 2500V max transient) |
| Maximum operation voltages | 90V to 264V (±10%) |
| Recommended dedicated circuit | 20 A for 120VAC or<br>10 Amps minimum for 230VAC<br>For more details, *Power Considerations*, page 8. |

## 6.2 CCD Camera (Optical Imaging)

Table 6.2 CCD camera specifications

| Item | Description |
|---|---|
| Sensor Type | Back illuminated |
| CCD Format | 2048 x 2048 pixels |
| CCD Size | 26 x 26 mm |
| Effective CCD Format | 1920 x 1920 pixels |
| Pixel Dimensions | 13.5 x 13.5 µm |
| Quantum Efficiency | ~85% 400-700nm<br>>50% 350-900nm |
| Readout Noise | <5 electrons RMS |
| Dark Current | <100 electrons/s/cm$^2$ (-90 °C) |
| Minimum Detectable Luminance | <70 photons/s/sr/cm$^2$ |
| CCD Temperature | Nominal -90 °C |

## 6.3 Optics

Table 6.3 Optics specifications

| Item | Description |
|---|---|
| Lens f/stop | f/1 – f/8 |
| Field of view (FOV) | 4, 6.5, 13, 19.5, 22.5 cm |
| Resolution | >60 µm (FOV = 3.9, f/1) |

## 6.4 X-ray Source

The X-ray source is an Oxford Instruments Series 5000 tube with a 0.005 inch thick beryllium window and a tungsten target.

Table 6.4 X-ray source specifications

| Item | Description |
|---|---|
| High voltage | 50kV |
| Max anode current | 1mA |
| Max anode power | 50W |

## 6.5 X-ray Detector

Table 6.5 X-ray detector specifications

| Item | Description |
|---|---|
| Sensitive area | 229.8 x 64.6 mm |
| Resolution | 3072 x 864 |
| Pixel binning modes | 1x1, 2x2, 4x4 pixels |
| Mean dark current (high saturation mode) | <17 electrons/pixel/second at 40 °C |
| Mean dark current (high sensitivity mode) | <17 electrons/pixel/second at 40 °C |
| MTF | >40% at 3 Lp/mm: >10% at 6 Lp/mm |
| System noise | 7.5 analog to digital units |
| Linearity (high sensitivity mode) | ± 4% |
| Linearity (high saturation mode) | ± 3% |

## 6.6 Fluorescent Imaging Components

Table 6.6 Fluorescent imaging components specifications

| Item | Description |
|---|---|
| Excitation filters | 12 positions, 25 mm diameter, 11 (ND2) filters supplied standard |
| Emission filters | 22 positions, 60 mm diameter, 18 filters supplied standard |
| Background (autofluorescence and leakage) | 1 part in 107 typical |
| Lamp | 150W quartz halogen<br>21VDC<br>3250° Kelvin |

## 6.7 Environmental Temperature and Humidity

Table 6.7 Environmental temperature and humidity specifications

| Item | Description |
|---|---|
| Temperature | 18 -24 °C (65-75 °F) |
| Humidity | 0-80% non-condensing |
| Type of use | Indoor (Pollution Decree 2) |
| Sound level | 61 dB < 500 Hz |
| Stage temperature | Ambient to 40 °C |
| Altitude rating | <2000 meters (6560 ft.) |

## 6.8 Weight and Dimensions

Table 6.8 Weight and dimension specifications

| Item | Description |
|---|---|
| Weight | 334 kg (735 lbs) |
| Depth | 77 cm (30 in.) |
| Width | 65 cm (25.5 in.) |
| Height | 206 cm (77 in.) |
| Imaging chamber internal dimensions | 51 x 51 x 66 cm (D x W x H) |

# 7 IVIS® Spectrum CT Components

*CCD Camera for Optical Imaging* on page 29
*X-ray Source, Detector, and Filters* on page 30
*X-ray System Control Panel* on page 30
*Key Selector Switch and Lost Keys* on page 31
*Thermoelectric Chiller* on page 31
*Imaging Chamber* on page 32
*Optical Components* on page 32
*Specimen Warming System* on page 34
*Rotating Stage and Anesthesia Connections* on page 34
*X-ray Door and Panel Interlocks* on page 38
*Base Enclosure* on page 39
*Acquisition Computer* on page 39
*High Reflectance Hemisphere* on page 39

The IVIS Spectrum CT includes the following components:

- Scientific imaging charged coupled device (CCD) camera
- Imaging chamber with specimen warming system
- Thermoelectric camera cooling system
- A pattern illuminator for animal positioning
- System of lenses and filters for bioluminescent image acquisition
- Photographic illumination system
- Integrated fluorescence system for fluorescent image acquisition
- An X-ray generating source, X-ray detector, and rotating animal stage for CT imaging

These components are integrated into one freestanding instrument that is equipped with casters (Figure 7.1).

**Figure 7.1** IVIS Spectrum CT Imaging System

A pre-configured Windows-based computer enables you to control the system as well as acquire and analyze images.

**IMPORTANT: If you modify the IVIS Imaging System in any way, without prior approval from Caliper, all warranties that cover this product are void. In addition, the computer included with the IVIS Spectrum CT is specifically configured to run all system-related applications. Any modification of existing software or hardware voids all warranties.**

If you have any questions, please contact Caliper technical support.

## 7.1 CCD Camera for Optical Imaging

The camera is a scientific grade, thermoelectrically-cooled, back-thinned, back-illuminated, large format CCD manufactured for Caliper. The camera uses a thermoelectric water chiller. Two flexible plastic water lines connect the CCD camera to the thermoelectric chiller unit.

The CCD camera has a heated, vacuum sealing window to prevent condensation that can obscure the image or damage other components.

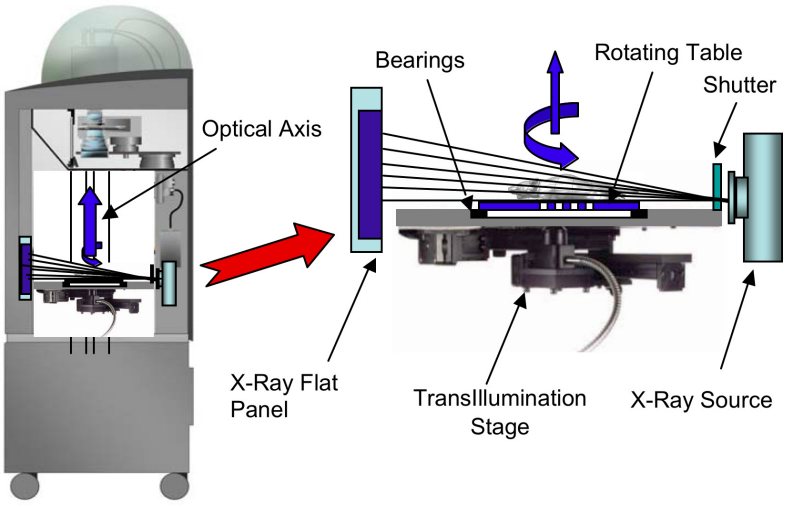
The camera power supply is housed in the base of the instrument and maintains the camera operating temperature when the computer is turned off. It has a 16-bit digitized, low-noise electronic readout for extremely low background images.

## 7.2 X-ray Source, Detector, and Filters

During CT Imaging, the animal stage moves to the lower compartment of the imaging chamber. The animal stage rotates while X-rays are generated from the X-ray source located at the rear of the IVIS Spectrum CT (Figure 7.2).

A series of images are collected by the detector located at the front of the instrument. During the brief period when the X-ray tube is warming up to its maximum voltage and current, a blocking filter is positioned so that the animal does not receive radiation prior to imaging. Image acquisition begins when the X-ray tube is at full power and a series of images is collected.

**Figure 7.2** X-ray source and detector




## 7.3 X-ray System Control Panel

The front panel located to the right of the imaging chamber door has two switches and two indicator lights that are associated with the instrument X-ray function. The main ON/OFF switch that controls the electrical power to the instrument is on the rear of the IVIS® Spectrum CT. Activating this switch provides power to the instrument, but does not permit the X-ray source to be energized unless the following conditions are met:

1. The imaging chamber door is completely closed and locked by the solenoid lock.
2. All interlocks are closed and panels mounted.
3. The Emergency Stop switch is in the ON (out) position. See the note below.
4. The key selector switch is turned ON.
5. The amber switch has been pushed and the light is ON, indicating that all safety interlocks are functioning properly.

The X-ray source cannot be energized from the Living Image software until these conditions have been fulfilled.

**NOTE:** The Emergency Stop switch is not intended as a main X-ray source control and should not be used to turn the X-ray function ON or OFF on a routine basis. It should only be used in the unlikely situation where the X-ray source must be immediately turned off. Under normal circumstances, it should be left in the ON position.

## 7.4 Key Selector Switch and Lost Keys

X-ray safety regulations require controlled access to the IVIS® Spectrum CT. The objective of this requirement is to prevent untrained and unauthorized personnel from operating the X-ray functionality of the instrument. The key-operated switch on the IVIS Spectrum CT fulfills this requirement when used in conjunction with the user's own written radiation safety procedures. The switch is designed so that the key can only be removed in the OFF position. When an authorized user is finished using the instrument, the key should be removed from the switch.

Two keys are provided with the instrument. A "master key" person usually manages the keys. It is a good practice to store the spare key in a safe location. If the keys are lost, contact Caliper technical support.

## 7.5 Thermoelectric Chiller

The thermoelectric unit is a thermoelectric water chiller (Figure 7.3). Water from the thermoelectrically-cooled CCD camera is pumped to the thermoelectric chiller where the water is cooled and returned to the camera.

**Figure 7.3** Thermoelectric Chiller

## 7.6 Imaging Chamber

The imaging chamber is a highly specialized device consisting of the imaging chamber housing, moveable platform with a rotating CT imaging stage, a lens system with f/stop control, and synchronized filter wheels that control the spectral content of the luminescent or fluorescent images (Figure 7.4).

**Figure 7.4** Imaging Chamber

An LED-based illumination system provides the means to acquire photographic information before imaging. The imaging chamber is equipped with gas anesthesia inlet and outlet ports for use with the optional Caliper XGI-8 Gas Anesthesia System.

The imaging chamber is light tight so that no light penetrates from the outside after the door is locked. The solenoid latch ensures that the door cannot be inadvertently opened during an imaging session.

The interior of the imaging chamber is constructed from non-phosphorescent and non-fluorescent materials to prevent internal light contamination that could compromise sample measurements. The chamber and door are made from steel of sufficient thickness to prevent radiation leakage.

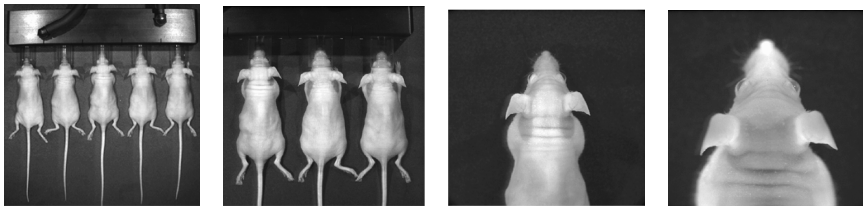
**WARNING! Under no circumstances should you attempt to make any mechanical modifications to the imaging chamber, the door, or the interlock switches.**

## 7.7 Optical Components

### Imaging System/Lenses

The IVIS® Spectrum CT is equipped with a rotating lens carousel that provides demagnification of 1.5X, 2.5X, 5X, and 8.8X power (Figure 7.6).The filter wheel settings are selected in the Living Image® software. For more details, see the *Living Image® Software Manual for the IVIS® Spectrum CT* (part no. 134222).

**Figure 7.5** Field of View Examples



| | | | | |
|---|---|---|---|---|
| Power: | 8.8X | 5.0X | 2.5X | 1.5X |
| FOV: | 22.5 | 13 cm | 6.5 | 3.9 |
| Position | cm | C | cm | cm |

The automatic shutter and f/stop iris is integrated into the lens system. A window at the top of the imaging chamber protects the lenses and other optical components in the lens compartment from contamination. For more details on the care of this window, see *Cleaning the Lens Protection Window*, page 60.

**CAUTION: Do not touch the glass window or permit specimens to come in contact with the window, otherwise image quality may be impaired. If the window is struck by a hard object, it may crack or shatter.**

## Emission and Excitation Filters

There are two 11-position filter wheels. Filter settings are selected within the Living Image software. For more details on how to access the filter wheels and change filters, see page 60.

For fluorescent studies, the IVIS Spectrum CT Imaging System can illuminate a specimen from the top of the imaging chamber (*epi-illumination)* or from the bottom of the stage (*transillumination*). A 12-position excitation filter wheel module is located in the back of the instrument (not accessible to users). If the filters must be changed or the module requires service, contact IVIS Imaging Systems Technology Support. For more details on fluorescent imaging, see page 45.

**Figure 7.6** Filter Wheel

## 7.8 Specimen Warming System

The imaging platform is temperature-controlled to keep subjects warm during imaging. The temperature control is enabled after the instrument is powered on and initialized from the Living Image® software. The default temperature is 37 °C and is self-monitoring after the system is initialized.

The actual surface temperature of the padded, rotating animal stage may be lower than that of the imaging platform.

The imaging platform does not have active cooling. The platform may require up to 20 minutes to passively cool from 37 °C to ambient temperature.

## 7.9 Rotating Stage and Anesthesia Connections

Table 7.1 lists the types of anesthesia connections (manifolds) that are available. Each manifold is equipped with its own gas and exhaust tubes. The ends of the tubes have gendered fittings so that the gas and exhaust tubes cannot be connected incorrectly.

**IMPORTANT: Disconnect the manifolds at the gas block so that the gas tube is not inadvertently connected to the exhaust port. Animal death is the likely outcome if the mouse nose cone is connected to the vacuum exhaust.**

**Table 7.1** Anesthesia Manifolds

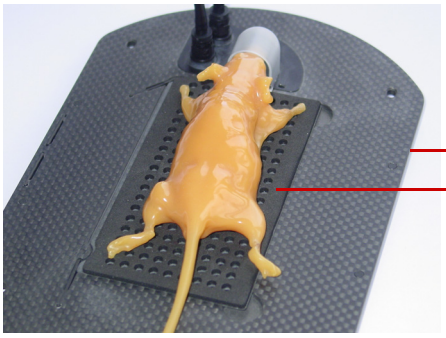
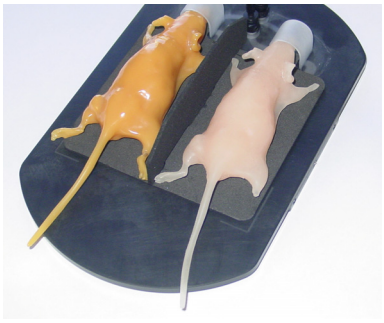
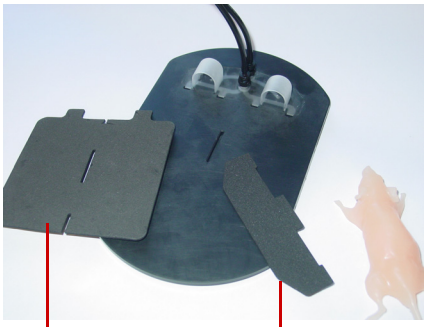
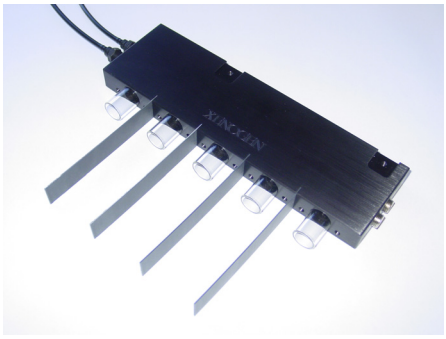
| Type | Description | For Use With These Imaging Modalities |
|---|---|---|
| Single Mouse Manifold |  One anesthesia nose cone is built into a stage which is placed on the imaging platform. Stage Bed (reduces X-ray scattering) | CT Luminescent Fluorescent with epi-illumination Fluorescent with transillumination |
| Dual Mouse Manifold |   Two anesthesia nose cones are built into a stage which is placed on the imaging platform. Bed (reduces X-ray scattering) Light baffle (prevents light from one mouse shining on the other) | CT Luminescent Fluorescent with epi-illumination |

**Table 7.1** Anesthesia Manifolds (continued)

| Type | Description | For Use With These Imaging Modalities |
|---|---|---|
| Five Mouse Manifold |  Animals are placed directly onto the imaging platform when using the Five Mouse Manifold. | Luminescent<br>Fluorescent with epi-illumination |

The Spectrum CT also accommodates the Mouse Imaging Shuttle (MIS, Caliper part no. 134366). The MIS can be used in CT imaging as well as luminescent or fluorescent (epi-illumination and transillumination) imaging. However, degradation of CT images can be expected due to the plastic walls of the MIS.

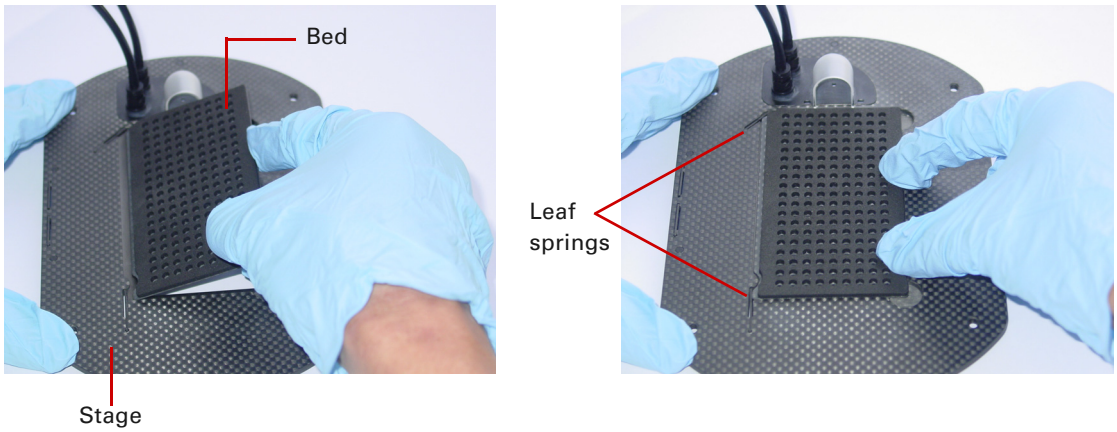
**CAUTION: Do not use the Mouse Imaging Shuttle with FOV A. The height of the shuttle could break the glass window at the top of the imaging chamber.**

## Single Mouse Manifold

The Single Mouse Manifold can be used with all imaging modalities. The manifold is integrated with a stage containing a low density composite foam and carbon fiber bed that reduces X-ray scatter during CT imaging.

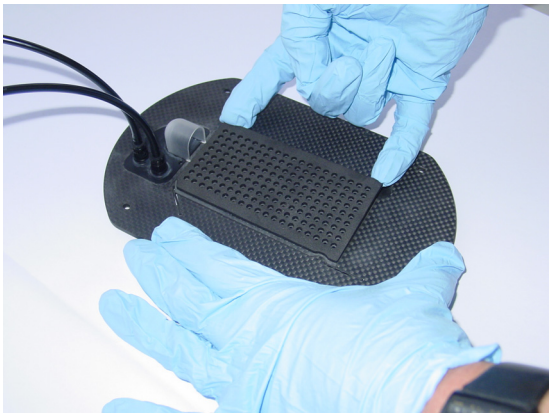
The bed has 171 holes which enable trans-illuminated fluorescence imaging. The bed is a delicate part and should be handled carefully. Figure 7.7 shows how to install the bed into the animal stage.

**Figure 7.7** Installing the Bed in the Single Mouse Manifold/Stage




Gently push the left edge of the bed against the edge of the stage cutout, then snap the bed down into place. The plastic leaf springs on the left side of the cutout will secure the bed.

**Figure 7.8** Removing the Bed from the Single Mouse Manifold/Stage



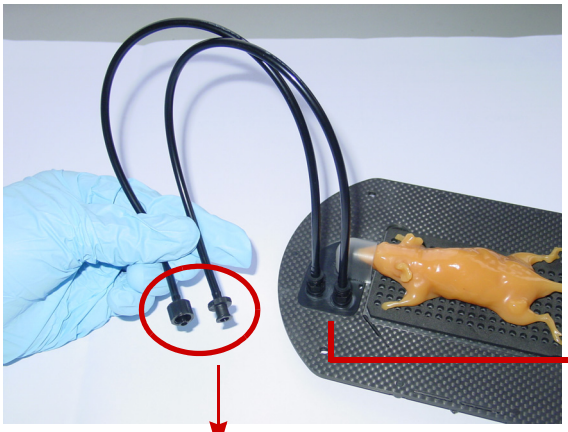
Gently lift up at the corners to remove the bed.

## Gas Connections

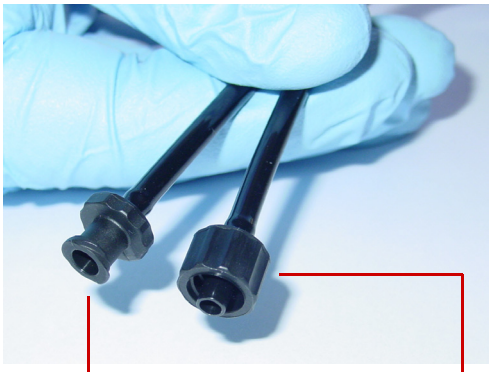
The distal ends of the gas tubes from the animal stage have gendered Luer fittings which prevent incorrectly connecting the tubes to the GAS and EXHAUST connections on the imaging platform (Figure 7.9).

**IMPORTANT: Disconnect the GAS and EXHAUST connections at the outlet port, not at the animal bed.**

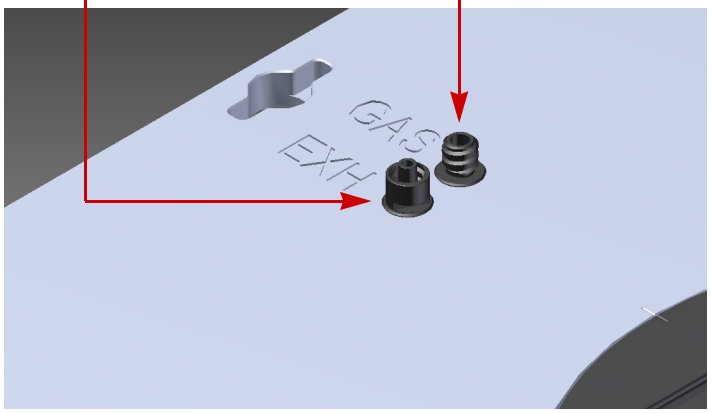
**Figure 7.9** Gas and Exhaust Luer Fittings



Do not disconnect the tubes here.



Connect the distal ends of the tubing to the mated GAS and EXHAUST fittings on the imaging platform.

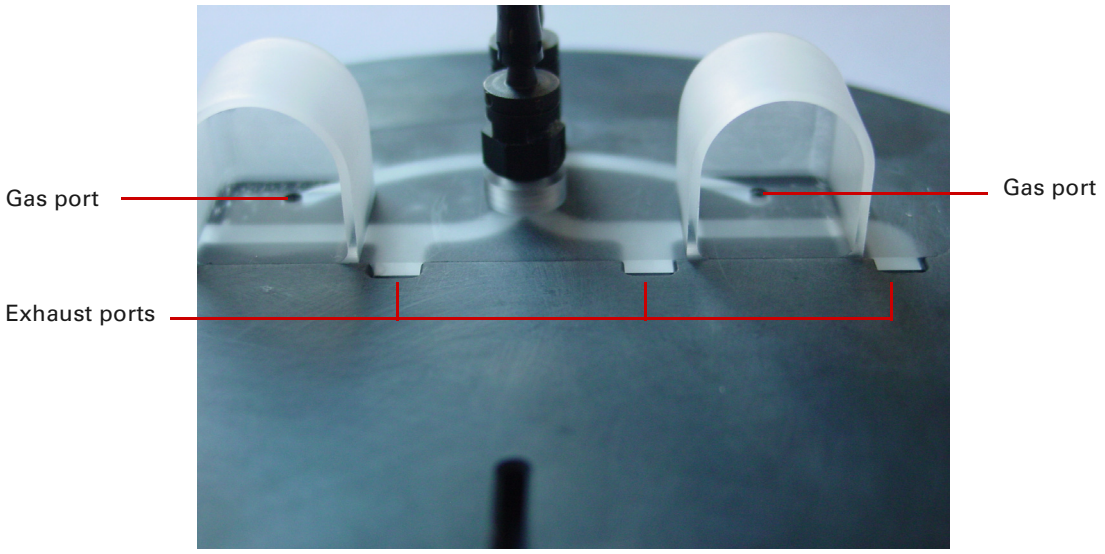


## Cleaning the Anesthesia Manifolds and Stages

**NOTE:** Do not allow fluids to get into the gas port and, especially, the exhaust port of the stage. Do not allow fluids to get into the interior of the manifold. It is recommended that you cover the ports with masking tape before cleaning or disinfecting the components. If fluid does enter the passages, try blowing it out.

**Figure 7.10** Dual Mouse Manifold — Gas and Exhaust Ports

There are two gas ports and four exhaust ports.




**To clean the anesthesia manifold and stage:**

1. Wipe the components with a cloth dampened with warm detergent.
2. Wipe the components with a cloth dampened with water.
3. To disinfect the manifold, spray with a 5% solution of bleach and distilled water. Do not allow fluids to enter the interior manifold passages.

**NOTE:** Beds and light baffles are not considered cleanable and should be replaced periodically.

# 7.10 X-ray Door and Panel Interlocks

A safety interlock prevents unintentional opening of the imaging chamber door (for more details, see Chapter 5, page 21). A solenoid interlock serves two functions, it: 1) acts as a switch which completes the electronic logic so that image acquisition can begin, and 2) mechanically locks the door during imaging so that it cannot be accidently opened.

These safety interlocks protect the user from X-ray exposure during CT imaging and protect the camera from overexposure to light during optical imaging.

A redundant switch with a removable copper rod cuts all power to the X-ray source should the door be opened and a solenoid switch failure occurs in the electrically ON state.

There are several other interlocks that protect the user from X-ray exposure when one or more of the electronic access panels are removed. The filter wheel access panel is interlocked. The interlock switch will break the X-ray power circuit if the user removes this panel for filter replacement or when

using the emergency imaging chamber access procedure described in Chapter 9, page 54. Two safety interlock switches protect the electronics bay on the right side of the instrument and the upper rear panel which encloses the X-ray source. These panels should only be removed by a Caliper service technician.

## 7.11 Base Enclosure

**IMPORTANT: Do not block the ventilation openings on the base of the IVIS Spectrum CT or position the instrument too close to a wall so that the exhaust flow is obstructed**

The base is equipped with four casters that enable you to move the instrument (Figure 7.11). For more details on how to move the IVIS® Spectrum CT, see page 65.

**Figure 7.11** Instrument base with casters

## 7.12 Acquisition Computer

The IVIS Spectrum CT Imaging System includes a Windows-based computer. The Living Image® software and Microsoft® Office software are installed on the acquisition computer. The Living Image software controls the IVIS Spectrum CT, and displays and analyzes the image data. A 20-inch monitor and a 10/100 Ethernet network adapter card are also included with the imaging system. A printer may be attached to the computer.

## 7.13 High Reflectance Hemisphere

The optional High Reflectance Hemisphere is used to check for light contamination in the imaging chamber (Figure 7.12). The hemisphere does not emit any photons when it is imaged in a light-tight and contaminant-free imaging chamber. As a result, it is not visible in a luminescent image.

If a light leak or an internal phosphorescent contaminant is present in the imaging chamber, the hemisphere reflects that light and is visible in a luminescent image. If you suspect light contamination in the imaging chamber, see "*Internal light contamination*" in Chapter 9, page 51. A light leak test is also a useful check for radiation leakage. If light can get into the imaging chamber, it is possible that X-rays could escape.

**Figure 7.12** High Reflectance Hemisphere

# 8 Operating the IVIS® Spectrum CT

*Starting the IVIS Spectrum CT*
*Restarting the System After a Power Outage* on page 43
*Gas Plumbing* on page 43
*Door Operation and Interlocks* on page 44
*Centering Subjects in the Field of View* on page 44
*Optical Imaging Basics* on page 45
*CT Imaging Basics* on page 47
*Normal System Shut Down Procedure* on page 48
*Emergency System Shutdown Procedure* on page 48

The IVIS Spectrum CT is intended for use in bioluminescent, fluorescent, and CT imaging procedures. The system is designed to detect extremely low-level light emissions that are orders of magnitude dimmer than can be detected by the naked eye. The IVIS Spectrum CT allows you to monitor and record cellular and genetic activity within a living organism, in real time. The imaging system captures, quantifies, and images the light emitted by a sample. Additionally, the computed tomography (CT) modality allows structural imaging of the subject.

## 8.1 Starting the IVIS Spectrum CT

All components of the IVIS Spectrum CT should be left on unless the system will not be used for more than 30 days. It is also important to leave the system on to enable automatic overnight electronic background measurements. Periodically rebooting the computer is permissible and does not affect camera operation.

Figure 8.1and Table 8.1 show the main console controls and indicators.

**Figure 8.1** Main console controls and indicators

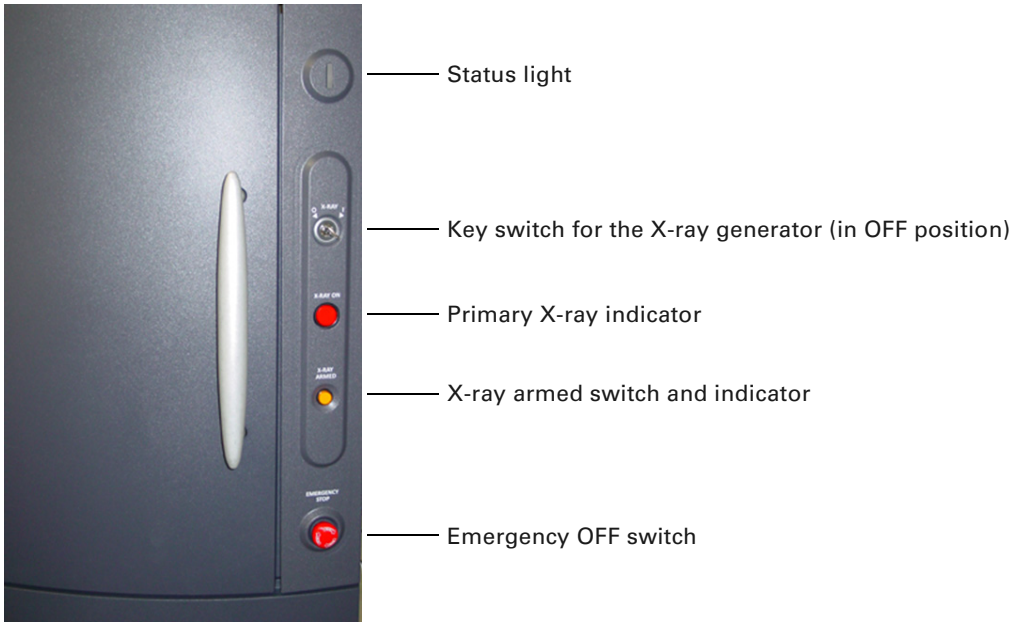
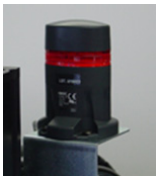

Status light
Key switch for the X-ray generator (in OFF position)
Primary X-ray indicator
X-ray armed switch and indicator
Emergency OFF switch

Table 8.1 Status lights and indicators

| Item | Location | Description |
|---|---|---|
| Status light | Front panel of the console | Indicates the general status of the IVIS Spectrum CT.<br>Green – The imaging system is ready.<br>Red – The imaging system is not ready. |
| X-RAY key switch | Front panel of the console | A key-actuated control which ensures that X-rays can only be generated when the key is in the ON (I) position. |
| Primary X-ray indicator | Front panel of the console | A red warning light that is illuminated when X-rays are being generated. |
| X-RAY ARMED button | Front panel of the console | This button must be pushed in to enable X-ray generation. |
|  X-ray ON indicator light | Under the top dome of the console | A red light which illuminates when X-rays are being generated and is visible from 360 degrees. |
| | IVIS Acquisition Control Panel in the Living Image® software | This icon appears in the IVIS Acquisition Control Panel when X-rays are being generated. |

**To start the IVIS® Spectrum CT:**

1. Turn on the instrument main power switch on the rear of the console.
2. Turn the key switch on the front console to the ON position.
3. Confirm that the EMERGENCY STOP switch is in the READY (out) position. If necessary, turn the knob clockwise to reset it to the READY (out) position.

**NOTE:** Pushing in the Emergency Stop switch cuts off power to the entire instrument so all functions stop, including the camera and motor driven components.

4. Push in the X-RAY ARMED button.

   When the imaging chamber door is shut, X-rays can be generated from the IVIS Acquisition Control Panel within the Living Image software on the acquisition computer.

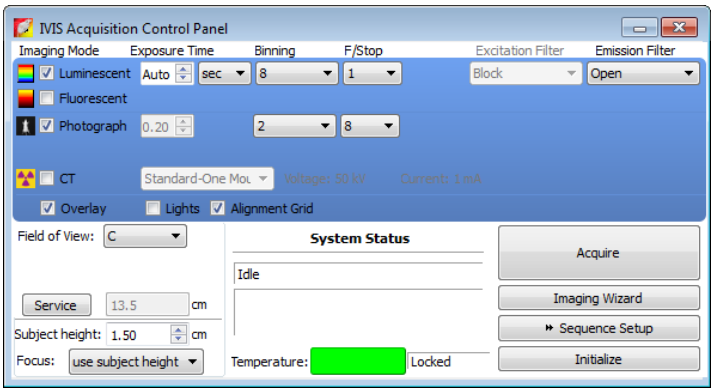
**NOTE:** For bioluminescent or fluorescent imaging, only the Emergency Stop switch must be in the READY (out) position.

## 8.2 Restarting the System After a Power Outage

The same procedure is used to restart the system after an intentional shutdown or shutdown due to a power outage.

1. Confirm that the rear panel switch is off, and the power cord is plugged into the console and the wall socket.
2. Turn on the main power switch on the rear panel.
3. Turn on the computer and monitor. Start the Living Image® software.
4. In the Living Image® software, click **Initialize IVIS System** in the control panel (Figure 8.2). The status light is red.

**Figure 8.2** Control panel in the Living Image software




5. Wait until the camera has cooled to operating temperature (requires about 10 minutes).

   You can monitor the system temperature in the Living Image software. The status light is green when the system is ready for operation.

## 8.3 Gas Plumbing

**WARNING! Use only isoflurane with the IVIS® Spectrum CT. DO NOT USE FLAMMABLE ANESTHESIA GAS.**

**CAUTION: Caliper recommends using the XGI-8 Gas Anesthesia System when imaging small animals (Figure 1.1 on page 2). This system supplies a controlled amount of isoflurane to the imaging chamber and continuously reduces the build-up of isoflurane in the chamber. If you plan to use a gas other than the recommended isoflurane/oxygen gas mixture or pure air, contact IVIS technical support.**

Be careful to use only tubing and other plumbing fixtures that do not fluoresce or phosphoresce (glow) in the imaging chamber. Please contact IVIS technology support for a list of acceptable materials.

The IVIS Spectrum CT is equipped with plumbing connections for supplying isoflurane anesthetic gas to the imaging chamber and exhausting gases out. The flow of gas into the imaging chamber is controlled by the gas valve on the front panel of the XGI-8. The imaging chamber does not include a gas scavenging system. This is provided by suitable auxiliary equipment such as the XGI-8 Gas Anesthesia System.

Gas ports are located on the rear of the system console and are labeled GAS IN and GAS OUT.

- GAS IN (white) – The direction of flow is into this port.
- GAS OUT (yellow) – The flow is exhausted out of this port.

The flow of gas from the rear panel GAS IN port is directed to a distribution block located on the imaging platform where it exits through the port labeled GAS.

Three mouse anesthesia manifolds are provided with the IVIS Spectrum CT. See Table 7.1 on page 34 for more details on these.

**CAUTION: Use only the manifolds provided with the IVIS Spectrum CT. Using other manifolds may cause damage to the instrument. Some manifolds for other Caliper imaging systems are taller and will break the lens window if the imaging platform is moved to Field of View A.**

The manifold port labeled GAS connects to the GAS port on the platform distribution block. The anesthesia manifold also has a port labeled EXH that should be connected to the EXH port on the platform distribution block. The vacuum or exhaust circuit connects to the GAS OUT port on the rear of the system console. No gases are exhausted from the imaging chamber unless gas scavenging equipment such as the Caliper XGI-8 Gas Anesthesia System is used.

## 8.4 Door Operation and Interlocks

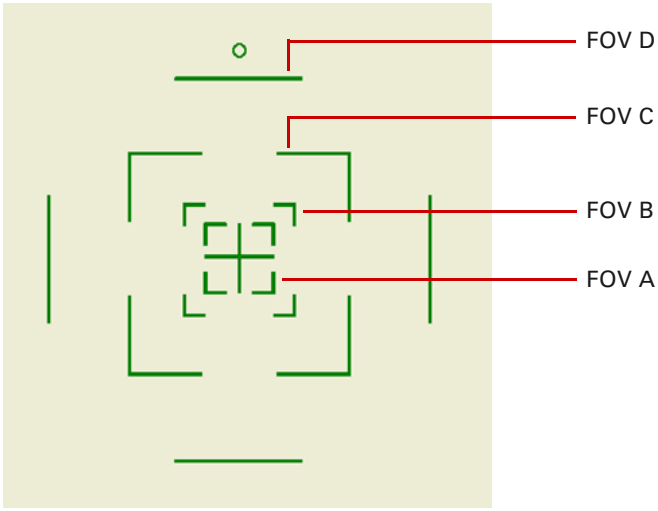
**WARNING! Never try to defeat the door interlock or force the door open during image acquisition when the status light is red or X-rays are being generated. Such action could expose the user to a severe pinch hazard from the rapidly moving imaging platform or dangerous levels of X-rays.**

After the system has been initialized, the door of the imaging chamber cannot be opened when the system status light is red. The door is equipped with a solenoid lock to prevent accidental opening during an imaging session. The solenoid lock serves two purposes: 1)locks the door during imaging including X-ray operation, and 2) acts as a primary interlock switch for X-ray operation. A second redundant interlock prevents X-ray generation when the door is opened or ajar. This redundant interlock operates by removing part of the X-ray circuit when the door is open. The copper rod attached to the door is the part that completes the circuit

## 8.5 Centering Subjects in the Field of View

A green illuminated pattern is projected onto the imaging platform when the instrument door is opened. The pattern of nested lines represents the field of view (FOV) A, B, C and D. It provides a helpful guide for centering subjects in the field of view.

**Figure 8.3** Pattern projected onto the imaging platform



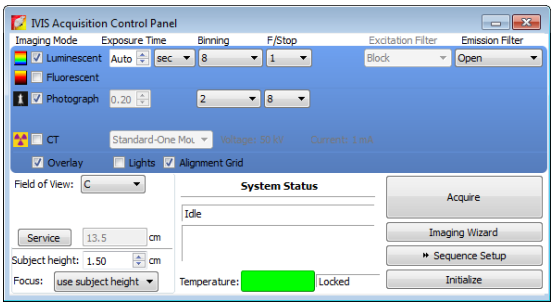

## 8.6 Optical Imaging Basics

The IVIS® Spectrum CT has both bioluminescent and fluorescent imaging capabilities. Optical imaging measures the light emitted by light-producing luminescent or fluorescent reporters such as luciferase or fluorescent proteins.

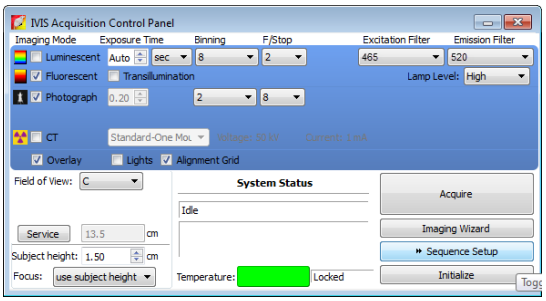
In the luminescent imaging mode, no excitation or emission filters are used. Selecting the "Auto" Exposure option in the control panel is recommended in most cases.

To change from luminescent to fluorescent operation, select fluorescent mode in the IVIS Acquisition Control Panel and select an appropriate excitation and emission filter (Figure 8.4).

**Figure 8.4** Control panel in the Living Image® software




Luminescent imaging mode




Fluorescent imaging mode

### Fluorescent Imaging

A 150 Watt quartz tungsten halogen lamp with a dichroic reflector provides the fluorescence excitation light. The Living Image® software controls the lamp intensity level. The fluorescence light source is a module located behind the rear panel and is not user serviceable.

The lamp output is delivered to the excitation filter wheel assembly located in the rear compartment, where it is collimated and transmitted through a fluorescence excitation filter. The 12 excitation filter wheel locations provide 10 fluorescence filters. One filter slot contains a light block that is used

during bioluminescent imaging to prevent external light from entering the imaging chamber. The 12-position excitation filter wheel is motorized and controlled through the Living Image software.

Upon leaving the excitation filter, the light enters an optical switch that directs the light to either the top of the imaging chamber (epi-illumination) or to the bottom of the stage (transillumination). When epi-illumination is selected, the light is split equally to four diffusers to provide uniform stage illumination. When bottom or transillumination is selected, the excitation light is directed to one of the holes in the aperture plate located in the stage surface. This removable plate has a 9 x 19 array of 3 mm diameter holes which provide discrete illumination locations that are user-selectable.

**NOTE:** Only the Single Mouse manifold can be used with transillumination.

Caliper provides optional accessories for alternative illumination use with the IVIS® Spectrum CT.

- Blank plate – For use with the 5 mouse manifold (compatible with epi-illuminated fluorescent imaging or luminescent imaging). The blank plate fits into a recess on the rotating turntable.
- Mouse Imaging Shuttle – Provides a means of transferring a single mouse between other imaging instruments and the IVIS Spectrum CT without disrupting the subject position. The shuttle also provides a small amount of compression to the mouse in order to enhance the optical signal levels.

See the *Living Image® Software Manual* for more details on how to use the epi- and transillumination systems.

### Selecting Emission and Excitation Filters

The IVIS® Spectrum CT includes a factory-installed filter set. The filters are mounted on a rotating filter wheels. For details on how to select an emission filter, see the *Living Image® Software Manual for the IVIS Spectrum CT* (part no. 134222).

Emission filters can be removed or replaced with filters with other spectral characteristics. For information on how to replace a filter, see *Changing the Emission Filters for Fluorescence Imaging*, page 60.

The excitation filters are housed in a filter wheel module that is not accessible to the user. Unlike the emission filters, the user cannot replace these filters. Contact Caliper technical support if an excitation filter must be replaced.

## Black Paper

Although the platform is black anodized, it is recommended that you image items on a high quality black paper, especially biological specimens. Caliper has surveyed many types of paper and recommends Swarthmore, Artagain, Black, part no. 445-109, size 8.5 inch x 11 inch (Caliper part no. 117837). This paper prevents illumination reflections and helps keep the stage clean. It can be cut with scissors to make non-luminescent background of custom shapes.

## Low Fluorescence Mat

When operating the system in the fluorescent mode, use the Low Fluorescence Imaging Mat (part no. 119000, set of 10) to reduce background fluorescence. The mat is made from a low reflectance textured plastic that is easily cleaned. The plastic mat can be cut with scissors to make non-fluorescing background of custom shapes.

### Glowing Materials

Always keep in mind that nearly EVERYTHING glows (that is, has the potential to phosphoresce and contaminate the image). Most plastics, almost all tape, plants, paint, rodent food (mostly plants), mouse urine, and animal bedding have been found to glow.

Use caution when introducing materials into the IVIS Spectrum CT. It is advisable to prescreen all items by imaging them alone, before imaging them with samples under study. Caliper recommends using non-powdered gloves when working with IVIS Spectrum CT equipment.

## 8.7 CT Imaging Basics

Computed Tomography imaging is an X-ray based imaging modality that is used to generate a 3D process. During image acquisition, projection images (planar X-ray images) are acquired from a series of perspectives. For the Spectrum CT, the orientation for each projection represents the angle of the animal with respect to the center line from the X-ray source (at the back of instrument) to the X-ray detector (at the front of the instrument). This stack of project images is then reconstructed to generate a 3D image of the physical object.

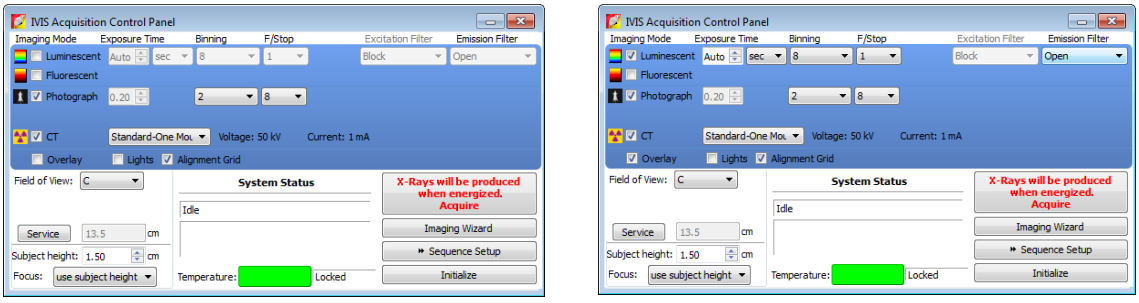
The image reconstruction process assumes that the animal does not move during acquisition. As a result, the motion caused by breathing and heartbeat causes inherent degradation of the image resolution which is seen as blur.

The X-ray based imaging process can also cause artifacts. X-rays also attenuate in a variety of materials in proportion to the linear attenuation coefficient and the amount of material in the X-ray path. The linear attenuation coefficient (μ) is related to the atomic number (Z) and is often normalized to density (ρ) and then represented as the mass attenuation coefficient (μ/ρ). Therefore, materials which are large and dense can result in artifacts. Furthermore, materials with a high atomic number and/or high density (for example, stainless steel) can also create artifacts. To minimize all of these potential pitfalls:

- Stabilize the animal as much as possible.
- Image only biological tissues.
- Avoid metal, including ear tags.

Select CT mode in the IVIS Acquisition Control Panel to perform CT imaging or include CT imaging with luminescent or fluorescent imaging (Figure 8.4).

**Figure 8.5** Control panel in the Living Image® software




CT imaging mode

Luminescent and CT imaging mode

## 8.8 Normal System Shut Down Procedure

Caliper does not recommend power cycling the IVIS® Spectrum CT (turning the system components off and on) on a daily basis. Leaving the system on keeps the camera cold and the electronics systems stable. The software is preconfigured to run automatic background accumulation and self-diagnostics overnight. The platform temperature and the computer monitor may be turned off.

If it is necessary to shut down the system for any reason, such as long term storage (more than 30 days), it is important to follow the procedure below.

1. Close the Living Image® software and save any information of interest at the prompt.
2. Turn off the computer.
3. Turn off any gas to the imaging chamber and disconnect the gas supply if necessary. If you are using the XGI-8 Gas Anesthesia system, follow the shutdown procedure in the *XGI-8 Anesthesia System User Manual*.
4. Turn off the main circuit breaker switch located on the rear of the IVIS Spectrum CT and disconnect the power cord from the wall socket.
5. Cover the gas inlet and outlet ports with masking tape to prevent entry of dust.
6. Remove any loose objects from the imaging chamber and close the door. If you plan to move the system, see important information on page 65. If you have any problems during the shutdown procedure, please contact IVIS technical support.

## 8.9 Emergency System Shutdown Procedure

In the event of an emergency where the IVIS® Spectrum CT must be shut off immediately, push in the red mushroom-shaped Emergency Stop switch located on the main console control panel (Figure 8.6).

**Figure 8.6** Emergency Stop button

To enable the system for restarting, turn the switch in a clockwise direction, and allow the knob to pop out. Restart the IVIS Spectrum CT following the procedure in *Restarting the System After a Power Outage* on page 43.

# 9 Troubleshooting

*Measured Temperature is not Equal to the Demand Temperature*

*Photographic Image is Unacceptable*

*Luminescent Image is Unacceptable* on page 51

*No Optical Image is Produced* on page 51

*No CT Image is Produced* on page 52

*Hardware Problems* on page 52

*Accessing the Area Under the Imaging Platform* on page 53

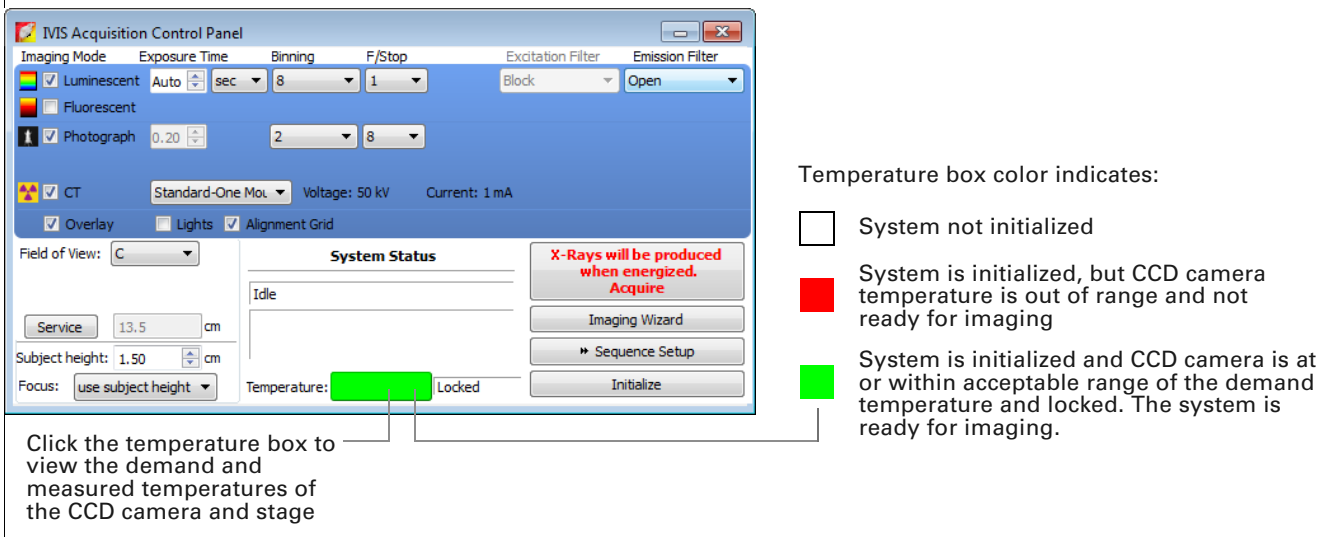
*Imaging Chamber Emergency Access* on page 54

## 9.1 Measured Temperature is not Equal to the Demand Temperature

At start up, the Living Image® software programs the CCD camera to maintain the CCD temperature at -90 °C.

To check the temperature of the CCD, click the Temperature square (red or green) in the Camera Control Panel of the Living Image software (Figure 9.1

**Figure 9.1** IVIS Acquisition Control Panel




## 9.2 Photographic Image is Unacceptable

Default camera controls are programmed during the initialization of the Living Image® software. Changes to these settings can greatly affect the photographic image. Confirm that the f/stop and binning levels are set to the default conditions.

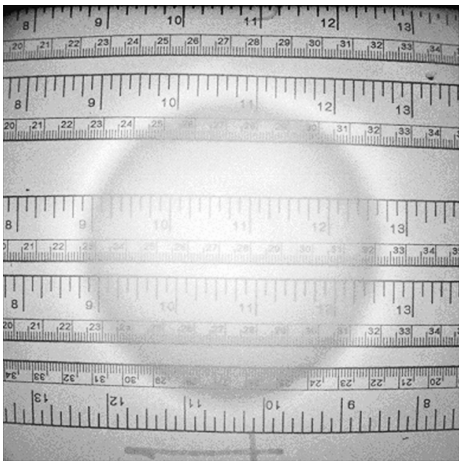
If you have questions about the photographic settings, please contact Caliper technical support.

Refer to the *Living Image® Software Manual for the IVIS® Spectrum CT* (part no. 134222) for further details on acquiring images.

Table 9.1 Troubleshooting photographic images

| Problem | Possible Cause | Corrective Action |
|---|---|---|
| Image is streaked. | Subject moved during the exposure. | Check to see if the subject may have moved. If the subject is not on the sample stage, it is probably on the floor of the imaging chamber. If the sample has moved, locate and re-anesthetize it. If gas anesthesia is being used, confirm that the anesthesia is turned on and the flow rate is appropriate. |
| Image is blurry. | Subject height is not correctly entered in the Living Image software. | If you are using the "Sample Height" setting to determine the focus, confirm that the correct height of the sample is entered.<br><br>If you are using the "Manual" setting to determine the focus, confirm that the focus has been manually adjusted. The f/stop for photographs should be set to f/8. An f/stop smaller than 8 reduces the depth of field in the photograph. |
| A white spot appears in the center of the field of view. | An excessively moist environment in the imaging chamber can result in condensation on the CCD window (Figure 9.2). | Remove excess moisture in the imaging chamber and allow it to thoroughly dry. Place a desiccant in the imaging chamber to decrease the drying time. Do not touch or let specimens touch the window at the top of the imaging chamber. For more details on the care of this window, see page 60. If the problem persists, contact Caliper technical support for assistance. |

**Figure 9.2** Example photograph showing the result of condensation on the CCD window



## 9.3 Luminescent Image is Unacceptable

Binning, f/stop, and exposure time affect the appearance of a luminescent image. Please see the *Living Image® Software Manual* for instructions on setting binning, exposure time, and f/stop values.

In order to function properly and reduce camera noise, the CCD camera must be cooled to the demand temperature before acquiring an image. If the camera is not cooled to the demand temperature, imaging may result in false positive signals.

Table 9.2 Troubleshooting luminescent images

| Problem | Corrective Action |
|---|---|
| Camera noise | Verify that the camera is cooled to the demand temperature.<br>1. Check the measured temperature in the Camera Control panel to ensure that it is locked. If the camera temperature is locked, the camera temperature box is green.<br>2. If the camera temperature box is red, click the red box to display the actual temperature. See "*Measured Temperature is not Equal to the Demand Temperature*", page 49. |
| Internal light contamination | Check to see that there are no extraneous light sources inside the imaging chamber. Many substances phosphoresce when exposed to light. Be especially cautious of plastics and substances that contain pigment. Be sure to prescreen any substance or material before performing actual experiments. |
| External light contamination | A 2" diameter High Reflectance Hemisphere (Figure 7.11 on page 39) is available from Caliper to help check for light leaks (XRH-1, Caliper part no. 118937).<br>To check for light leaks:<br>3. Place the high reflectance hemisphere in the imaging chamber on the stage using a subject height of 3.5 cm at field of view D.<br>4. Take a luminescent image of the hemisphere using the luminescent settings: f/stop = 1, Binning = Large (high sensitivity), and exposure time = 5 minutes.<br>If the hemisphere can be easily seen, there is a light leak. Contact Caliper technical support for assistance. |

**WARNING! If there is a light leak in the imaging chamber based on a test using the High Reflectance Hemisphere, there is also a strong possibility that X-rays may be leaking from the chamber. For this reason, do not use the IVIS Spectrum CT in CT mode until a radiation survey has been completed.**

## 9.4 No Optical Image is Produced

If no optical image is produced, there may be an error in the Living Image® software, a problem with the physical connections to the camera, or a hardware failure. To troubleshoot the problem:

1. Close the Living Image software and restart the computer.
2. Restart the Living Image software and try to acquire an image.

If no image was produced after restarting the computer, contact Caliper technical support.

## 9.5 No CT Image is Produced

Verify that the X-rays were "armed".

Verify that nothing has been left on the shelf that could block X-rays (for example the 5-port manifold), then perform the steps listed above in *No Optical Image is Produced*.

## 9.6 Hardware Problems

Most of the components in the IVIS Spectrum CT are not user-serviceable due to the integrated design of the instrument.

**VOLTAGE! Do not remove any panel from the IVIS® Spectrum CT, except for the filter wheel access panel or the lower rear cart panel. Removing a panel could expose the user to hazardous voltages.**

The procedure for removing the filter wheel access panel is described on page 60. Removing the lower rear cart panel for access to the chiller is described on page 62.

If you suspect a problem with the instrument hardware, contact Caliper technical support.

### Circuit Breaker (Power Entry Module)

Under normal operation, the circuit breaker that is incorporated into the rear panel power entry module (main power switch) should not trip. Frequent tripping of this circuit breaker may indicate an underlying electrical problem. If this occurs, unplug the system and contact Caliper technical support.

If the circuit breaker is occasionally tripped, perform the following steps.

1. Confirm that the rear panel switch is off, and the power cord is plugged into the console and the wall socket.
2. Turn on the rear panel main power switch.
3. Turn on the computer and, if necessary, start the Living Image® software.
4. Initialize the system (click **Initialize** in the control panel within the Living Image software).

   The status light is red and turns green when the system is initialized. Wait until the camera has cooled to the demand temperature before acquiring images.

### Computer and Camera Connections

Never disconnect or wiggle the rear panel computer or camera connections when the IVIS Spectrum CT is powered on. If you suspect that any of the rear panel computer connections are loose, follow the steps below.

1. Close the Living Image software and shut down the computer.
2. Turn off the X-ray key switch.
3. Turn off the rear panel circuit breaker switch.
4. Check the connections between the computer and the rear panel of the IVIS Spectrum CT. Tighten any loose connection.
5. Turn on the rear panel main power switch.

   The status light is red.
6. Turn on the computer and start the Living Image software.
7. Initialize the system (click **Initialize** in the control panel within the Living Image software).

The status light is red and turns green when initialization is complete. Wait until the camera has cooled to the demand temperature before acquiring images.

### Pattern Illuminator

The pattern illuminator is not user-serviceable. If you notice any changes to the alignment grid (for example, change in the brightness or position of the grid), contact Caliper technical support.

### Lamp Replacement

The quartz halogen lamp that provides the fluorescent light source typically operates for thousands of hours, depending on the lamp level (low or high). This light source is housed in a compartment that contains hazardous voltages and is not user accessible or serviceable.

**VOLTAGE! DO NOT attempt to service the quartz halogen lamp.**

If the lamp brightness is decreased or if lamp replacement is required, contact Caliper technical support.

## 9.7 Accessing the Area Under the Imaging Platform

During normal operation, the imaging platform always returns to the loading position before the door can be opened. This helps ensure user safety and convenience when loading subjects. Occasionally you may need access to the area beneath the platform for cleaning or to retrieve a subject. Since the platform moves rapidly and produces strong forces, the area beneath the platform is not accessible unless the normal operation mode is overridden.

**To access the space below the imaging platform:**

1. Remove all items from the imaging stage that are taller than 2 cm and close the door.
2. In the IVIS Acquisition Control panel, click **Service** button.
   The platform moves to the service position and the door can be opened.
3. Place the stage lock down bar in position (Figure 9.3).
   Be careful not to disturb the platform heater cable or the gas tubing located in this area.

**To return the platform to the operating position:**

1. Return the lock down safety bar to the stowed position under the front edge of the imaging platform and close the door.
2. In the IVIS Acquisition Control panel, click the **Load** button.
   The imaging platform returns to the normal operating position.

**Figure 9.3** Stage lock down bar

The stage lock down bar is located at the bottom front edge of the imaging platform (stowed position).

Pull the bar down from the stowed position and place it as shown above. Return the bar to its stow position before returning the imaging platform to the operating position.

## 9.8 Imaging Chamber Emergency Access

There is a remote possibility that the solenoid door lock could fail in the locked position which would prevent you from opening the imaging chamber door after an imaging session. If this occurs, the solenoid can be manually deactivated using a special key provided by Caliper.

**CAUTION: If the solenoid door lock fails, do not use the IVIS® Spectrum CT after the solenoid is mechanically deactivated. Contact Caliper technical support for a solenoid replacement (page 3).**

### Initial Steps

If you are unable to open the imaging chamber door, first try to disengage the lock by cycling through a few brief imaging sessions while pushing and pulling on the door handle. If this fails, turn the power on and off several times at the main power switch on the rear of the instrument.

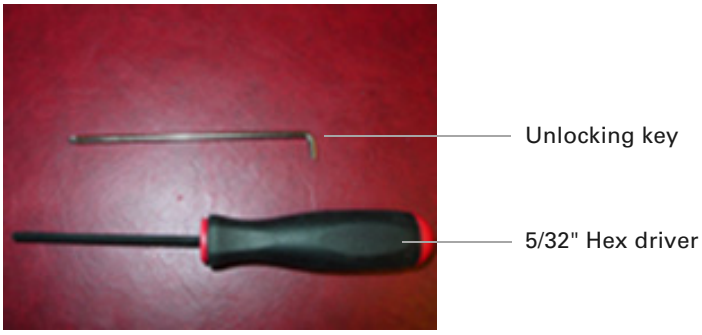
If these attempts do not disarm the solenoid, follow the steps below to mechanically deactivate the solenoid.

### Mechanically Deactivating the Solenoid

This procedure requires the Emergency Access Kit (part no. 133881) which includes a:

- 5/32" Hex driver (part no. 133880) (Figure 9.4)
- Solenoid unlocking key (part no. 133533)

**Figure 9.4** Tools required for deactivating the solenoid lock

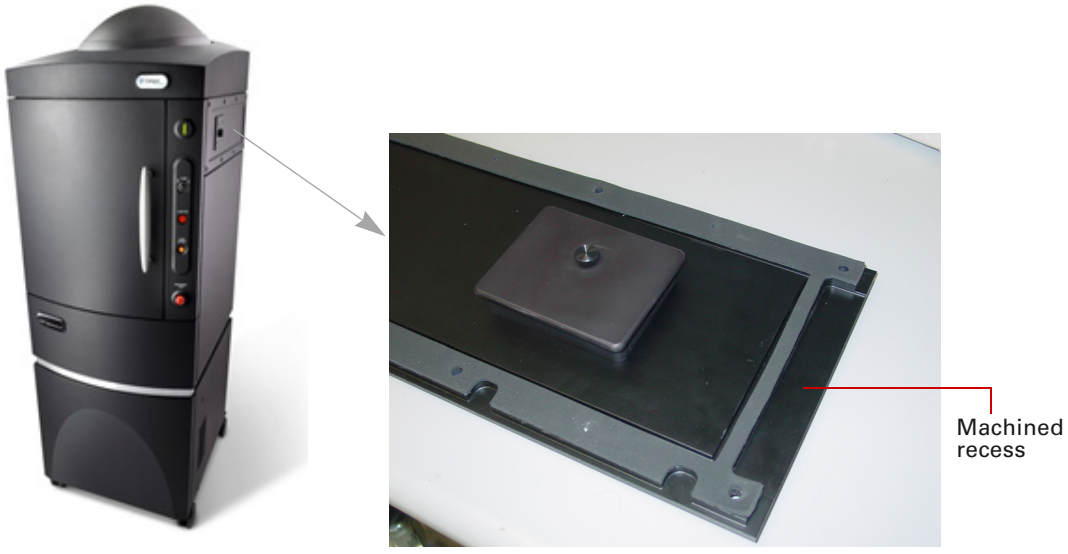



1. Save any data within the Living Image® software, then exit the program.
2. Turn off the main power at the rear of the system console.
3. Using the 5/32" hex driver, remove the eight screws that hold the filter access panel in place on the upper right side of the console (Figure 9.5).

   The panel is held in place by four pins until it is pulled forward.

   Be careful not to damage the light-sealing gasket when removing the panel.

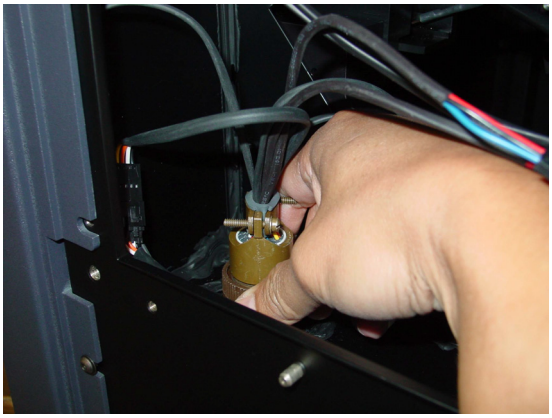
**Figure 9.5** Filter wheel access panel



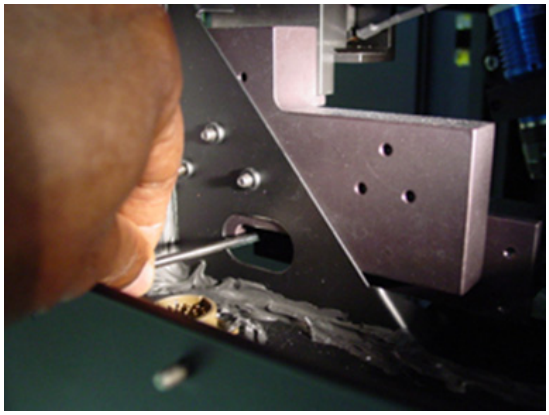

   The filter access panel has a machined recess on the inner left-hand side (towards the front of the console). Noting this orientation is helpful when you reinstall the panel (Figure 9.5).
4. Disconnect the electrical connector towards the front of the IVIS® Spectrum CT by rotating the knurled ring counter clockwise (Figure 9.6).
5. After the electrical connector is removed, locate the triangle-shaped rotating key receptacle.

   One vertex of the triangle has a small dot that points to LOCK (Figure 9.7).

**Figure 9.6** Disconnecting the electrical connector and inserting the unlocking key into the key receptacle

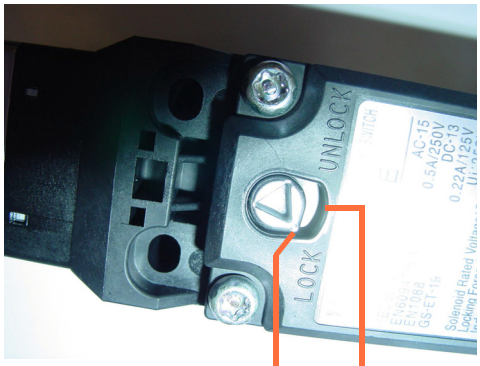


Disconnect the electrical connector to access the key receptacle.



Insert the unlocking key through the aperture in the sheet metal.

**Figure 9.7** Key receptacle and solenoid unlocking key




Dot on the key receptacle

Key receptacle in the LOCK position

Unlocking key inserted into the key receptacle

6. Insert the unlocking key into the triangular receptacle and turn the key counter-clockwise to so that the dot on the key receptacle points to the UNLOCK position (Figure 9.7).

   The solenoid will mechanically disengage.

7. Open the door and remove the subject(s) from the imaging chamber.
8. Using the key, return the solenoid to the LOCK position by fully turning the key in the clockwise direction.
9. Reinstall the electrical connector. Make sure that it is fully engaged.
10. Replace the filter wheel access panel.

**CAUTION: Do not use the IVIS® Spectrum CT after mechanically deactivating the solenoid lock. Contact Caliper technical support for a solenoid replacement (page 3).**

# 10 Care and Maintenance

*Surveying the IVIS Spectrum CT for Radiation Leakage*
*Maintenance and Safety Checks*
*Cleaning the IVIS® Spectrum CT* on page 58
*Changing the Emission Filters for Fluorescence Imaging* on page 60
*Servicing the Chiller Unit* on page 62
*Moving the System* on page 65

## 10.1 Surveying the IVIS Spectrum CT for Radiation Leakage

Caliper recommends, and some local government agencies may require, that you perform an X-ray leakage safety test under the following conditions:

- Every 12 months
- When the system is installed at a new site requiring truck transport. Moving the IVIS Spectrum CT on its casters should not require a re-survey.
- After Caliper performs maintenance or service.
- After any abnormal condition that could impair any of the safety systems. For example, if the imaging chamber door becomes difficult to open or close.

### Conducting the X-Ray Radiation Survey

A radiation leakage test is a complicated matter requiring sensitive and expensive equipment. Some states or localities may require special training and certification to perform the test. Contact Caliper technical support for information regarding these tests or for scheduling a Caliper-trained technician to conduct the survey as part of an overall safety check.

## 10.2 Maintenance and Safety Checks

### Daily Safety Checks

The following safety checks should be performed on a daily basis.

1. Verify that the door interlocks discussed in *Safety Interlocks* on page 21 are in good repair.
2. Verify that the key switch functions properly.
3. Verify that the following "X-ray ON" indicators are functioning properly when the X-ray modality is used. These include the:
   - Red light on the front control panel
   - Red light under the translucent dome at the top of the instrument
   - "X-ray ON" indicator in the IVIS Acquisition Control Panel in the Living Image software
4. Verify that the amber "X-ray armed" indicator light is working.
5. Light leak check (see page "*External light contamination*", page 51).

### Weekly Safety Checks

The following safety checks should be performed on a weekly basis.

1. All of the daily safety checks.
2. Inspect the solenoid lock and the redundant interlock assembly and make sure that it has not loosened. Inspect the screws holding the two mating keys.
3. Inspect the metal knife edges on the door and the light box for damage such as bending.
   The knife edges keep X-rays inside the light box and prevent light from entering.

### Monthly Safety Checks

The following safety checks should be performed every month.

1. All daily safety checks.
2. All weekly safety checks.
3. Activate the "Emergency Stop" switch to verify operation.

   All indication of X-ray generation should cease when the switch is pushed in.

**NOTE:** This will cut all power. X-rays will need to be generated to perform this test.

4. Reset the Emergency Stop switch by turning the red knob clockwise. The knob should pop out.
5. Initialize the system.
6. Re-arm the X-ray source and restart X-ray generation from the Living Image® software.

### Annual Safety Checks

The following safety checks should be performed every 12 months.

1. All safety checks performed on a daily, weekly, and monthly basis.
2. A full radiation survey performed by a qualified person.

## 10.3 Cleaning the IVIS® Spectrum CT

If necessary, wipe the exterior surface of the IVIS® Spectrum CT instrument with a soft cloth. If the system requires more aggressive cleaning or sterilization, contact Caliper technical support.

**DANGER! DO NOT use sprays or fluids to clean the exterior or interior of the module. Do not allow fluids of any kind to penetrate the electronics cabinet under any circumstances. Sprays and liquids that come into contact with the IVIS Spectrum CT may result in damage to the system or electrocution.**

**WARNING! Do not use fluids or moistened towels to clean any part of the instrument where electrical or fiber optic cables make connections. Do not use fluids of any kind near the filter wheel assembly. Turn off the electrical power to the IVIS Spectrum CT by turning off the rear panel switch before engaging in cleaning operations that use fluids. The imaging chamber power switch is located on the rear of the instrument.**

## Approved Cleaning Solutions

The compounds shown in Table 10.11 do not damage the internal finish of the IVIS Spectrum CT imaging chamber and are suitable as cleaners, if required. Do not use any solution not included in this list. In particular, avoid strong bases, bleach, or acids that may potentially damage the unit and compromise its operation.

**IMPORTANT: Do not spray cleaning solutions inside the imaging chamber.**

Table 10.1 Approved cleaning solutions for the imaging chamber

| Cleaning Solution | Manufacturer |
|---|---|
| Cidexplus® Solution (3.4% glutaraldehyde) | Johnson & Johnson Medical |
| Sporicidin® Sterilizing Solution (1.56% phenol) | Sporicidin International |
| Clidox-s® Disinfectant | Pharmacal Research Laboratories, Inc. |
| 70% methyl alcohol/30% deionized water solution | |
| 70% ethyl alcohol/30% deionized water solution | |

**NOTE:** Caliper makes no claims as to the sterility of the imaging chamber after cleaning with the solutions in Table 10.1. Please refer to the manufacturer's literature for information as to the applicability of the compound for the organism of interest. Consider dedicating an imaging system for immunodeficient animals. This will reduce the risk of cross contamination.

## Cleaning the Imaging Platform

It is recommended that you use a lint-free wipe, such as Scott Pure® wipe or a Kaydry EX-L® wipe to minimize the presence of particulate matter in the imaging chamber.

After saturating a lint-free wipe, clean the internal surfaces using a gentle circular motion. Do not pour or spray the solution directly onto internal surfaces. Rinse surfaces using a wipe saturated with sterile deionized water. Do not allow puddles of water to remain on the surfaces.

Avoid cleaning the ceiling of the image chamber except when necessary. When cleaning the chamber ceiling, use extreme care to avoid damaging the lens protection window and the light diffusers in this area.

To avoid any phosphorescence from the cleaner, make sure that the surfaces are dry before using the imaging chamber.

## Cleaning the Rotating Stage

It is particularly important not to allow any liquids to drip into the rotating stage assembly. The stage is mounted on a precision bearing that can become corroded over time if it is exposed to water or other cleaning liquids.

### Cleaning the Lens Protection Window

Please contact Caliper technical support for information about cleaning or sterilizing any of the optical components or replacing the optical filters. A clear window at the top of the imaging chamber protects the lenses and other optical components from contamination. Do not touch or allow subjects to touch this window, otherwise image quality may be impaired. Further, the glass window could be cracked or broken if struck by a hard object. The lens protection window should be cleaned periodically.

**To clean the surface of the lens protection window:**

1. Blow off any accumulated dust using a Dust-Off® compressed gas duster.
2. Dampen a lint-free cloth with isopropyl alcohol and gently swab the window surface to remove any smudges or streaks.
3. Repeat Step 2 using a clean area of the cloth or a new cloth until the window is clean.
4. Take an image to confirm that the image quality is restored.

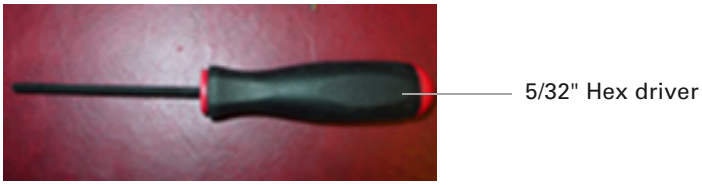
## 10.4 Changing the Emission Filters for Fluorescence Imaging

This section explains how to change one or more of the optional emission filters used for fluorescence imaging in the IVIS® Spectrum CT.

**NOTE:** After changing a filter or a filter position, you must also change the corresponding filter label in the Living Image® software. For more details, see the *Living Image® Software Manual for the IVIS® Spectrum CT* (part no. 134222).

1. Before you begin, gather the following tools:
   - 5/32" hex key
   - #2 Phillips head screw driver
   - One pair of lint free, powderless gloves

**Figure 10.1** Tools required for deactivating the solenoid lock



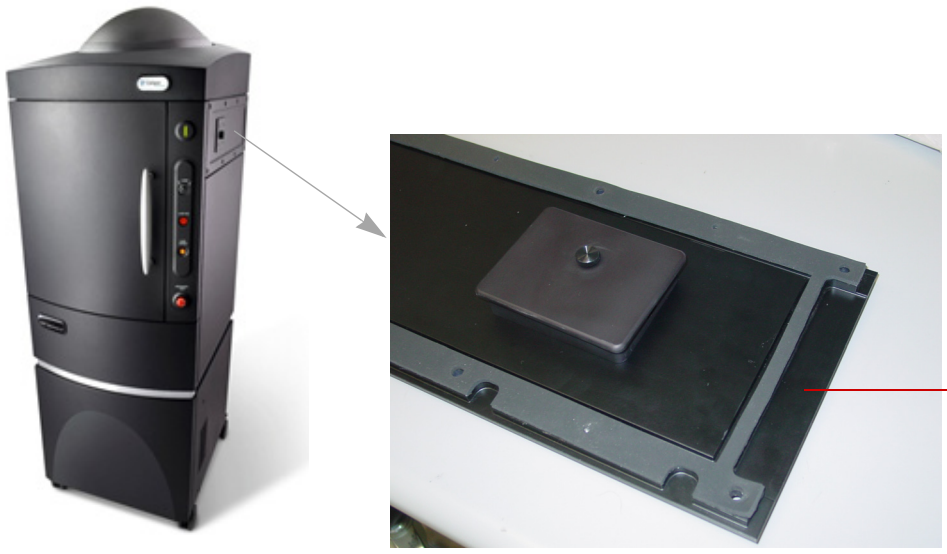

2. In the Living Image® software, save any important data, then exit the program.
3. Turn off the main power at the rear of the instrument.
4. Using the 5/32" hex key, remove the eight screws that hold the filter access panel in place on the upper right side of the instrument (Figure 10.2).

   The panel is held in place by four pins until it is pulled forward.

**CAUTION: Be careful not to damage the light-sealing gasket when removing the panel.**

**NOTE:** The panel has a machined recess on the inner left-hand side (towards the front of the instrument). Noting this orientation is helpful for reinstalling the panel.

**Figure 10.2** Filter wheel access panel




**NOTE:** Starting with step 5, wear lint-free, powderless gloves to prevent smudging the filters.

5. Notice that the 1/2" shaft on the right side of the filter wheel compartment has a carriage clamp lock with a handle. Turn the handle counter-clockwise to loosen the clamp so that it can slide freely over the shaft.
6. Grip the filter wheel by the metal rim and pull the filter wheel carriage forward until it stops. Be careful not to touch the glass filters or to dislodge the two drive belts.

   Since the carriage slides out about eight inches, only two or three of the filters will be visible. The filter wheel holds the filters numbered 1-11.
7. To remove a filter from the filter wheel:
   a. Slowly rotate the filter wheel until the filter of interest is exposed.
   b. Use a #2 Phillips head screw driver to loosen the flat head screw ONE TURN.

      The screw has a captured O-ring that retains the glass emission filter.
   c. Use two gloved fingers to remove the filter. Alternatively, gently push the filter up with a gloved finger.
8. To clean a filter, use Dust-Off® compressed gas to apply an air stream at an angle to the filter surface; otherwise dust particles could be driven into the filter coating.

**CAUTION: Do not blow air onto a filter in the filter wheel as dust could be spread to other optical components**

9. To install a filter, insert the filter into the filter wheel recess and tighten the O-ring screw until it bottoms out (about one turn).

**NOTE:** Make sure that the filter retaining screw and O-ring are fully seated to prevent interference or rubbing against components above them. The top of the filter metal ring should be nearly flush with the wheel. The filter encapsulating metal ring has one side that is thinner than the other. The thin part of the ring should face downward in the wheel recess so that the arrow that is printed on the side of the filter points up.

10. Push the filter wheel carriage back into the instrument by placing one finger on the rim of the upper filter wheel.

11. While holding the carriage in the closed position, turn the carriage-locking clamp in the clockwise direction. Be careful not to dislodge any drive belts off of their pulleys when locking the clamp.
12. Replace the access panel by positioning it onto the four pins. The inner machined out recess should be on your left side.
13. Loosely install the eight screws, then lightly tighten the four central screws and in a crisscross pattern. Lightly tighten the four outer screws in a crisscross pattern.

**NOTE:** Do not over tighten the screws. The panel is designed to seal out light without large clamping force.

14. Restart the system following the procedure on on page 43.

## 10.5 Servicing the Chiller Unit

The coolant level in the chiller unit may diminish over time and require replenishing. It is recommended that you check the coolant level in the chiller unit every six months. This section explains how to prepare and add coolant to the chiller unit.

### Required Items

The following tools and items are required, but not provided.

- Allen Wrench (hex head wrench): 3/32" measured across the flats (AF).
- A disinfecting coolant mixture of 25% pure ethanol and 75% distilled water.

  To prepare 750 ml: Mix 200 ml of 190 proof ethanol and 550 ml of distilled water.

  If pure ethanol is not available, a suitable substitute can be made from ordinary 80 proof vodka and distilled water. To prepare 750 ml of disinfecting coolant: Mix 470 ml of 80 proof vodka (40% ethanol) and 280 ml of distilled water.

**WARNING! When preparing the ethanol solution, adhere to the 25% (by volume) pure ethanol concentration. A higher alcohol concentration may be flammable and a lower concentration may not suppress organic growth in the cooling system or camera.**

- Paper towels or cloth for clean up.
- The coolant fill bottle supplied with the IVIS® Spectrum CT.

### Coolant Replenishment Procedure

**VOLTAGE! Do not remove any panels from the console until you turn off the IVIS Imaging System and disconnect the power cord. Only trained personnel should perform the following procedures. Serious risk of electric shock is possible if instructions are not followed completely.**

1. Turn off electric power to the main console:
   a. Turn off the main power switch on the rear panel and disconnect the console power cord from both the wall socket and the imaging console.
   b. Move any cables away from the lowest rear panel of the console so that the panel can be removed (Figure 10.3). (No other cables need to be removed.)

**Figure 10.3** Lower rear panel – power cord removed

2. Remove the console rear panel:
   a. Use a 3/32" hex head wrench to remove the screws that secure the bottom rear (fan) panel (Figure 10.2).
   b. Carefully remove the panel and lean it against the side of the console.

**CAUTION: Be careful not to pull too hard on the rear fan panel, otherwise its electrical connector may become disconnected. If this happens, contact Caliper technical support).**

**Figure 10.4** Remove the lower rear panel using a hex head wrench to expose the chiller unit

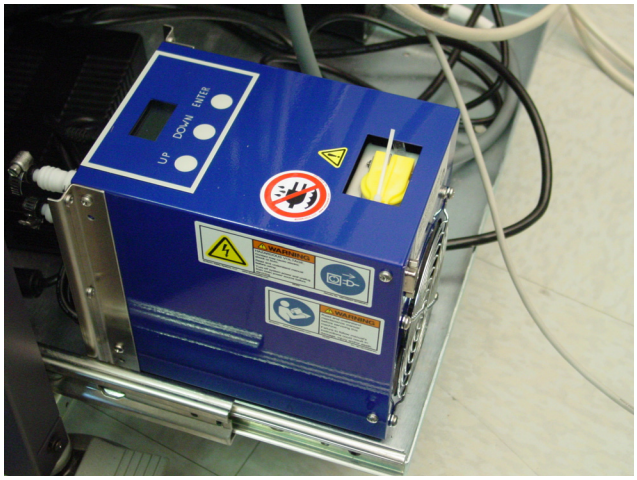
The chiller unit sits on a tray that must be pulled out to access the unit.

3. To access the chiller:
   a. Move any cables or tubes out of the way so that the tray with the chiller can be pulled out freely.

**b.** Pull out the tray with the chiller (Figure 10.4).

**NOTE:** The chiller unit has its own power switch located at the rear of the unit. The power switch is not visible until the unit is pulled out. Make sure that the power switch is not accidentally turned off when you slide the tray out or back into the console

**Figure 10.5** Pull out the chiller unit tray




**c.** Remove the chiller unit from the tray and place it on the floor.

**4.** Pull up the chiller fill cap and check the coolant level (Figure 10.6).
The coolant should be visible.

**5.** Add coolant if necessary:

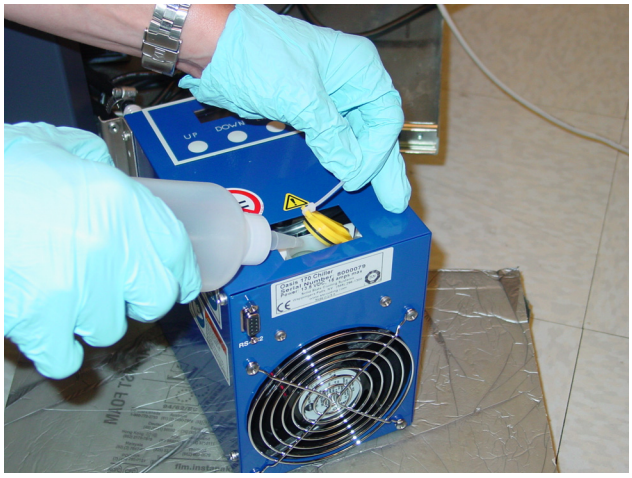
**CAUTION: DO NTO OVERFILL the chiller. Over filling the tank can cause the fluid to run down the chiller walls and contact the power plug.**

**a.** Using the fill bottle, add small quantities of the 25% ethanol/75% distilled water solution to the tank until the coolant level reaches the bottom of the fill port.
Be careful not to spill the liquid.

**b.** Wipe away any liquid from the top or walls of the chiller.

**c.** Close the chiller cap.

**Figure 10.6** Filling the chiller with coolant



6. Return the chiller to the tray and slide the tray back into the console while holding hoses and cables out of the way to prevent snagging.
7. After the chiller is mounted in position, confirm that:
   - The chiller power switch is on and no tools or other hardware remain inside the instrument.
   - The cap is secure.
   - No fluids have spilled onto the chiller or the Spectrum CT pull out shelf.
8. If any fluid is present, wipe it off before proceeding to the next step.Replace the lower rear panel using a 3/32" hex head wrench to tighten the screws (Figure 10.4 on page 63).\
9. Restart the IVIS Spectrum CT:
   a. Confirm that the instrument rear panel power switch is OFF.
   b. Reconnect the power cord first to the console and then to the wall socket.
   c. Confirm that all other cables are properly connected.
   d. Turn on the computer.
   e. Turn the rear panel power switch ON.
   f. Start the Living Image software and initialize the system.

      The status light is red and turns green when the system is initialized.

      Wait until the camera has cooled to the demand temperature before you begin an imaging session (approximately 10 - 20 minutes).

# 10.6 Moving the System

## Removing the Dome

It may be necessary to remove the plastic camera dome when you move the IVIS® Spectrum CT though a doorway or other low overhang.

To remove the dome, wrap a flat blade screw driver with a thin cloth or paper towel and use the screw driver to gently pry the dome off at the rear of the instrument.

## Moving the System

If the instrument is only repositioned a short distance within the range of the power cord and cables, the power need not be turned off. However, be careful not to accidentally turn off the power when gripping the system at the right rear.

When possible, two people should move the IVIS Spectrum CT. The instrument is tall and it is difficult to see potential obstacles when pushing the instrument from behind. Make sure that the path is clear of items that could jolt the casters and cause the instrument to tip. Move the instrument slowly so that you are always in control of its motion.

**To move the system:**

1. Turn off the main power switch on the rear panel of the instrument, and disconnect the power cord from the wall socket and the instrument.
2. Remove all cables from the rear panel of the instrument.

   **CAUTION: Any cables that dangle from the instrument could cause the system to topple if caught by a caster.**

3. Unlock the four casters.
4. Grip the instrument at a convenient location, but do not use the door handle as a grip. Be careful when gripping the right rear of the instrument so that you do not damage the connectors or fan grills.
5. After the system is positioned at the new location, lock the casters.
6. Reconnect the cables and power cord.
7. If necessary, reinstall the dome.
8. Restart the system:
   a. Confirm that the rear panel power switch is off and all cables are reconnected.
   b. Confirm that the power cord is plugged into the instrument and the wall socket.
   c. Turn on the rear panel main power switch.
   d. Turn on the computer and start the Living Image® software.
   e. Initialize the system (from within the Living Image software).

      The status light is red.

      The status light turns green when the system is initialized. Wait until the camera has cooled to the demand temperature before you begin an imaging session (about 10 minutes).

# 11 Contact and Ordering Information

*PerkinElmer Contact Information*
*Ordering Information*
*US Radiation Authorities* on page 69
*Canadian Radiation Authorities* on page 78

## 11.1 PerkinElmer Contact Information

### Technical Support

**Telephone** 1.877.522.2447 (US)
1.508.435.9500

**E-mail** tech.support@caliperls.com

**Fax** 1.508.435.3439

**Mail** Caliper Life Sciences
US Corporate Headquarters
68 Elm Street
Hopkinton, MA 01748

### Caliper Sales

To order replacement parts, contact Caliper at:

**Telephone** 1.508.497.3302

**E-mail** order.entry@caliperls.com

**Fax** 1.508.435.0967

**Mail** Sales Order Management
Caliper Life Sciences
68 Elm Street
Hopkinton, MA, 01748
USA

## 11.2 Ordering Information

Table 11.1 Ordering information

| Item | Part No. |
|---|---|
| Black Paper, Swarthmore, Artagain, 9x12" 24 Sheet pad | 117837 |
| Kit, Foam Animal Beds, Single Mouse, 3mm holes (set of 10) | 134371 |
| Kit, Foam Animal Beds and Light Baffles, Dual Mouse Manifold (set of 10) | 134372 |

Table 11.1 Ordering information (continued)

| Item | Part No. |
|---|---|
| Kit, Animal Bed Substrate (2mm holes) with Lamination Instructions | 134377 |
| Light Baffle, Foam, Dual Mouse Manifold | 134151 |
| Kit, Tools for Emergency Access to Spectrum CT Imaging Chamber | 133881 |
| Low Fluorescence Imaging Mats, 11.6" square (set of 10) | 119000 |
| Mouse Inhalation Nose Cones for 5 Port Manifold (set of 10) | 119001 |
| Light Baffle, 0.5” High (single) | 117151 |
| Light Baffle, 0.7” High (single) | 117152 |
| XRS-10 Rubber Stoppers for 5 Mouse Manifold (set of 10) | 119006 |
| XNC-LP Rat Nose Cones, 5 Port Manifold (For FOV B, C, and D only) | 119025 |
| Optical Lens Cleaner | 123495 |
| Wipe, Lint Free (50/package) | 126291 |
| Phantom Mouse, XFM-2 CT-FLIT | 133803 |
| XRM-5, Phantom, Mouse, XRM-5X-Ray (simulates fat, inner bone, cortical bone, solid water) | 133793 |
| Assembly, Phantom, Mouse, XPM-2 CT-DLIT | 133805 |
| XLS-4 Calibrated Light Source | 118897 |
| XRH-1 High Reflectance Hemisphere with Container | 118937 |
| XGI-8 Anesthesia System, 120Volt | 118918 |
| XGI-8 Anesthesia System, 230Volt | 118919 |
| XGI-8 Anesthesia System, 100Volt | 118957 |
| XPM-2 Bioluminescent Phantom Mouse | 118993 |
| XWS-248 Workbench (48" wide) | 119208 |
| XWS-260 Workbench (60" wide) | 119207 |
| XWS-272 Workbench (72" wide) | 119212 |
| Kit, Mouse Imaging Shuttle, Spectrum CT | 134366 |
| Kit, Animal Bed Lamination Flxture and Instructions | 134375 |
| Kit, Rotation Stage Alignment (measures shelf, pitch and yaw alignment) and Instructions | CLS135992 |

# 11.3 US Radiation Authorities

Table 11.2 US Radiation Authorities

| |
|---|
| **ALABAMA**<br>Office of Radiation Control<br>State Dept. of Public Health<br>201 Monroe St/PO Box 303017<br>Montgomery, AL 36130-3017<br>334-206-5391<br>http://www.adph.org/radiation/ |
| **ALASKA**<br>Radiologic Health Program<br>4500 Boniface Parkway<br>Anchorage, AK 99507-1270<br>907-334-2107<br>http://www.hss.state.ak.us/dph/labs/radiological/ |
| **ARIZONA**<br>Arizona Radiation Regulatory Agency<br>4814 South 40th St.<br>Phoenix, AZ 85040-2940<br>602-255-4845 Ext. 222<br>http://www.arra.state.az.us/ |
| **ARKANSAS**<br>Arkansas Department of Health<br>Radiation Control Section<br>4815 W. Markham St., Slot H-30<br>Little Rock, AR 72205-3867<br>Phone: 501-661-2301<br>www.healthyarkansas.com/rtl |
| **CALIFORNIA**<br>Radiologic Health Branch<br>Division of Food & Radiation Safety<br>PO Box 997414, MS-7610<br>Sacramento, CA 95899-7414<br>916- 440-7899<br>http://www.cdph.ca.gov/programs/Pages/RadiologicHealthBranch.aspx |
| **COLORADO**<br>X-Ray & Mammography Compliance<br>Registration & Certification<br>4300 Cherry Creek Drive South<br>Denver, CO 80246-1530<br>303-692-3446<br>http://www.cdphe.state.co.us/hm/rad/xray/ |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **CONNECTICUT**<br>Dept. of Public Health<br>Division of Radiation<br>79 Elm Street<br>Hartford, CT 06106-5127<br>860-424-3029<br>http://www.dep.state.ct.us |
| **DELAWARE**<br>Office of Radiation Control<br>Division of Public Health<br>417 Federal Street<br>Dover, DE 19903<br>302-744-4546<br>http://www.dhss.delaware.gov/dph/hsp/orc.html |
| **DISTRICT OF COLUMBIA**<br>Department of Health<br>HRLA/Radiation Protection Div.<br>717 14th Street NW, Room 639<br>Washington, DC 20005<br>202-724-8800<br>http://hrla.doh.dc.gov/hrla/site/default.asp |
| **FLORIDA**<br>Dept. of Health/Bureau of Radiation Control<br>4052 Bald Cypress Way, Bin C21<br>Tallahassee, FL 32399-1741<br>850-245-4266<br>Radiologic Technology Program<br>4052 Bald Cypress Way<br>Tallahassee, FL 32399-1741<br>850-245-4540<br>www.doh.state.fl.us/environment/radiation |
| **GEORGIA**<br>Department of Human Resources<br>2 Peachtree Street NW, 33rd Floor<br>Atlanta, GA 30303-3142<br>404-657-5400<br>http://ors.dhr.georgia.gov/portal/site/DHR-ORS/ |
| **HAWAII**<br>Dept. of Health./Noise & Radiation Branch<br>591 Ala Moana Blvd.<br>Honolulu, HI 96813-4921<br>808-586-4700<br>Radiation Section<br>Radiological Response/Radiologic<br>Technology/Mammography<br>808-586-4700<br>http://hawaii.gov/health/environmental/noise/radiationsection/radiation.html |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **IDAHO**<br>Dept. of Health & Welfare<br>Idaho Bureau of Laboratories<br>2220 Old Penitentiary Rd.<br>Boise, ID 83712-8299<br>208-334-2235 ext.245<br>http://healthandwelfare.idaho.gov/Health/Labs/Certification/tabid/186/Default.aspx |
| **ILLINOIS**<br>IL Emergency Management Agency<br>Division of Nuclear Safety<br>1035 Outer Park Dr.<br>Springfield, IL 62704<br>217-785-9868<br>Registration and Certification Section<br>217-785-6982/Fax 217-785-9946<br>http://www.iema.illinois.gov/iema/dns.asp |
| INDIANA<br>State Department of Health<br>Epidemiology Resource Center/<br>Indoor and Radiological Health<br>2525 North Shadeland Avenue, E3<br>Indianapolis, IN 46219<br>317-351-7190, Ext. 257<br>http://www.in.gov/isdh/23279.htm |
| **IOWA**<br>Bureau of Radiological Health<br>Lucas State Office Bldg., 5th Fl<br>321 E. 12th St.<br>Des Moines, IA 50309-4611<br>515-281-3478<br>http://www.idph.state.ia.us/eh/radiological_health.asp |
| **KANSAS**<br>Radiation Section<br>1000 SW Jackson St, Suite 310<br>Topeka, KS 66612-1366<br>785-296-1565<br>http://www.kdheks.gov/radiation/indexXray.html |
| **KENTUCKY**<br>Radiation Control Program<br>Cabinet for Health & Family Services<br>275 East Main Street, HS1C-A<br>Frankfort, KY 40621-0001<br>502-564-3700 Ext. 3695<br>http://chfs.ky.gov/dph/radiation.htm |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **LOUISIANA**<br>Emergency & Radiologic Services Division<br>PO Box 4312<br>Baton Rouge, LA 70821<br>225-219-3041<br>www.deq.louisiana.gov/portal/tabid/2283/Default.aspx |
| **MAINE**<br>Division of Environmental Health<br>Radiation Control Program<br>286 Water Street, 4th Floor<br>Augusta, ME 04333<br>Telephone: 207-287-5677<br>http://www.maine.gov/dhhs/eng/rad/ |
| **MARYLAND**<br>Radiologic Health Program<br>Maryland Dept of the Environment<br>1800 Washington Blvd., Suite 750<br>Baltimore, MD 21230-1724<br>410-537-3300<br>http://www.mde.maryland.gov/Programs/AirPrograms/Radiological_Health/ |
| **MASSACHUSETTS**<br>Radiation Control Program<br>Department of Public Health<br>Schrafft Center, Suite 1M2A<br>529 Main Street<br>Charlestown, MA 02129<br>617-242-3035<br>www.mass.gov/dph/rcp |
| **MICHIGAN**<br>Radiation Safety Section<br>Div. of Health Facilities & Services<br>Bureau of Health Systems<br>MI Dept. of Community Health<br>PO Box 30664<br>Lansing, MI 48909<br>517-241-1993<br>www.michigan.gov/rss |
| **MINNESOTA**<br>Section of Indoor Environments & Radiation<br>Division of Environmental Health<br>Department of Health<br>625 Robert Street N.<br>P.O. Box 64975<br>St. Paul, MN 55164-0975<br>651-201-4602<br>http://www.health.state.mn.us/divs/eh/radiation/xray/ |
| |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **MISSISSIPPI**<br>Division of Radiological Health<br>State Department of Health<br>3150 Lawson Street<br>Jackson, MS 39215-1700<br>601-987-6893<br>http://www.msdh.state.ms.us/msdhsite/_static/30,0,102.html |
| **MISSOURI**<br>Medical Radiation Control Program<br>Health Services Regulation<br>Division of Regulation and Licensure<br>PO Box 570<br>Jefferson City, MO 65102-0570<br>573-751-6083<br>http://www.dhss.mo.gov/RadProtection/ |
| **MONTANA**<br>Radiological Health Program<br>MT Dept. of Public Health and Human Services<br>Licensure Bureau<br>P. O. Box 202953<br>Helena, MT 59620-2953<br>406-444-2868<br>https://app.mt.gov/radio/ |
| **NEBRASKA**<br>Office of Radiological Health<br>Dept. of Health & Human Services<br>P. O. Box 95026<br>Lincoln, NE 68509-5026<br>402-471-0528<br>www.dhhs.ne.gov/rad |
| **NEVADA**<br>Radiological Health Section<br>Bureau of Health Protection Services<br>Nevada State Health Division<br>4510 Technology Way, Suite 300<br>Carson City, NV 89706<br>775-687-7540<br>http://health.nv.gov/HCQC_Radiological.htm |
| **NEW HAMPSHIRE**<br>Radiological Health Section<br>Division of Public Health Services<br>Dept. of Health and Human Services<br>29 Hazen Drive<br>Concord, NH 03301-6504<br>603-271-4585<br>http://www.dhhs.nh.gov/DHHS/RADHEALTH/default.htm |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **NEW JERSEY**<br>Radiation Protection Programs &<br>Release Prevention Element<br>Dept. of Environmental Protection<br>P. O. Box 415<br>Trenton, NJ 08625-0415<br>609-984-5636<br>http://www.state.nj.us/dep/rpp/index.htm |
| **NEW MEXICO**<br>Radiologic Technologist Cert. Program<br>New Mexico Environment Department<br>1190 St. Francis Drive<br>Santa Fe, NM 87502-0110<br>505-476-3264<br>http://www.nmenv.state.nm.us/nmrcb/radserv.html |
| **NEW YORK**<br>Office of Radiologic Health<br>2 Lafayette Street, 11th Floor<br>New York, NY 10007<br>212-676-1550<br>http://www.health.state.ny.us/environmental/radiological/radon/registration.htm |
| **NORTH CAROLINA**<br>North Carolina Radiation Protection Section<br>3825 Barrett Drive<br>Raleigh, NC 27609-7221<br>919-571-4141, Ext.232<br>http:///www.ncradiation.net |
| **NORTH DAKOTA**<br>Division of Air Quality<br>North Dakota Dept. of Health<br>918 E. Divide Avenue<br>Bismarck, ND 58501-1947<br>701-328-5188<br>www.ndhealth.gov/aq/rad |
| **OHIO**<br>Bureau of Radiation Protection<br>Ohio Dept. of Health<br>246 North High Street<br>Columbus, OH 43215<br>614-644-2727<br>http://www.odh.ohio.gov/odhPrograms/rp/radprot/radprot1.aspx |
| **OKLAHOMA**<br>Consumer Protection Services<br>State Department of Health<br>1000 Northeast Tenth Street<br>Oklahoma City, OK 73117-1299<br>405-271-5243 |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **OREGON**<br>Radiation Protection Services<br>Oregon Health Services,<br>Department of Human Services<br>800 NE Oregon Street, Suite 640<br>Portland, OR 97232-2162<br>971-673-0499<br>http://public.health.oregon.gov/Pages/Home.aspx |
| **PENNSYLVANIA**<br>Bureau of Radiation Protection<br>Rachel Carson State Office Bldg.<br>P.O. Box 8469<br>Harrisburg, PA 17105-8469<br>717-787-2480<br>http://www.dep.state.pa.us/brp/default.htm |
| **PUERTO RICO**<br>Radiological Health Division<br>Department of Health<br>P. O. Box 70184<br>San Juan, PR 00936-8184<br>787-274-7802<br>http://www.salud.gov.pr |
| **RHODE ISLAND**<br>Office of Facilities Regulation<br>Division of Environmental and Health Services<br>3 Capitol Hill, Room 206<br>Providence, RI 02908-5097<br>401-222-4520<br>http://www.health.ri.gov/hsr/facilities/radiological/index.php |
| **SOUTH CAROLINA**<br>Bureau of Radiological Health<br>Dept. of Health & Environment Control<br>2600 Bull Street<br>Columbia, SC 29201<br>803-545-4420<br>http://www.scdhec.gov/health/radhlth/x-ray.htm |
| **SOUTH DAKOTA**<br>Office of Health Care Facilities<br>Licensure and Certification<br>615 East 4th St.<br>Pierre, SD 57501-1700<br>605-773-3356<br>http://doh.sd.gov/Licensure/Default.aspx |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **TENNESSEE**<br>Division of Radiological Health<br>37911 Middlebrook Pike<br>Knoxville, TN 37921<br>Telephone: 865/594-5577<br>http://www.state.tn.us/environment/rad/ |
| **TEXAS**<br>Bureau of Radiation Control<br>State Dept of Health Services<br>PO Box 14937<br>Austin, TX 78714-9347<br>512-834-6679<br>http://www.dshs.state.tx.us/radiation/ |
| **UTAH**<br>Division of Radiation Control<br>168 North 1950 West<br>PO Box 144850<br>Salt Lake City, UT 84114-4850<br>801-536-4257<br>http://www.radiationcontrol.utah.gov/XRAY/reginspc.htm |
| **VERMONT**<br>Office of Radiologic Health<br>Department of Health<br>108 Cherry Street<br>PO Box 70<br>Burlington, VT 05402<br>802-865-7730<br>http://healthvermont.gov/enviro/rad/rad_health.aspx |
| **VIRGINIA**<br>Division of Radiological Health<br>Department of Health<br>James Madison Bldg.<br>109 Governor Street, Room 730<br>Richmond, VA 23219<br>804-864-8170<br>http://www.vdh.state.va.us/epidemiology/RadiologicalHealth/ |
| **WASHINGTON**<br>Office of Radiation Protection<br>Department of Health<br>PO Box 47827<br>Olympia, WA 98504-7827<br>360-236-3210<br>http://www.doh.wa.gov/ehp/rp/xray/reg.htm |

Table 11.2 US Radiation Authorities (continued)

| |
|---|
| **WEST VIRGINIA**<br>Radiological Health Program<br>Office of Environmental<br>Health Services<br>DHHR Bureau for Public Health<br>1 Davis Square, Suite 200<br>Charleston, WV 25301-1798<br>304-558-6721<br>http://www.wvdhhr.org/rtia/radiological_health.asp |
| **WISCONSIN**<br>Radiation Protection Section<br>Dept. of Health and Family Services<br>PO Box 2659<br>Madison, WI 53701-2659<br>608-267-4792<br>dhfs.wisconsin.gov/dph_beh/RadiatioP/Index.htm |
| **WYOMING**<br>Office of Healthcare Licensing<br>6101 Yellowstone Road, Suite #400<br>Cheyenne, WY 82002<br>(307) 777-7124<br>http://wdh.state.wy.us/main/divisionsprograms.html |

# 11.4 Canadian Radiation Authorities

**Table 11.1** Canadian Provincial/Territorial/Federal Radiation Protection Contacts (Non-medical X-rays)

| |
|---|
| **Prince Edward Island**<br>Environmental Health<br>Dept. of Health and Social Services<br>16 Garfield Street<br>PO Box 2000 Charlottetown<br>PE C1A 2N8<br>Tel: (902) 368-4792<br>Fax: (902 368-6468 |
| **Newfoundland and Labrador**<br>Department of Government Services<br>West Block, 4th Fl, Confederation Bldg<br>PO Box 8700<br>St. John's, NL A1B 4J6<br>Tel: (709) 729-0218<br>Fax: (709) 729-3445 |
| **New Brunswick**<br>Health Protection Branch<br>Department of Health<br>PO Box 5100<br>Fredericton, NB E3B 5G8<br>Tel: (506) 453-2424<br>Fax: (506) 453-8702 |
| **Nova Scotia**<br>Occupational Health and Safety Division<br>Department of Labour and Workforce Development<br>PO Box 697<br>Halifax, NS B3J 2T8<br>Tel: (902) 424-7115<br>Fax: (902)424-5640 |
| **Quebec**<br>CSST Quebec<br>Direction de la prevention-Inspection<br>Commission de la sante et de la securite du travail<br>524, rue Bourdages, local 250<br>CP 1200, succursale Terminus<br>Quebec, QC, G1K 7E2<br>Contact: Mrs. Candide Fournier<br>Tél: (418) 266-4699 ext. 2005 |

**Table 11.1** Canadian Provincial/Territorial/Federal Radiation Protection Contacts (Non-medical X-rays) (continued)

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| **Ontario**<br>Radiation Protection Service<br>Occupational Health and Safety<br>Ontario Ministry of Labour<br>81A Resources Road<br>Weston, ON M9P 3T1<br>Tel: (416) 235-5765<br>Fax: (416) 235-5926 |
| **Manitoba**<br>Head of Radiation Protection<br>Medical Physics Division<br>Cancer Care Manitoba<br>675 McDermot Ave<br>Winnipeg, MB R3E 0V9<br>Tel: (204) 787-2213<br>Fax: (204) 775-1684 |
| **Saskatchewan**<br>Radiation Safety Unit<br>Department of Labour<br>400 - 1870 Albert St<br>Regina, SK S4P 4W1<br>Tel: (306) 787-4538<br>Fax: (306) 787-2208 |
| **Alberta**<br>Radiation Health & Safety Specialist<br>Alberta Human Resources & Employment<br>10808-99th Ave, 8th Floor<br>Edmonton, AB T5K 0G5<br>Tel: (780) 415-0612<br>Fax: (780) 422-0014 |
| **British Columbia**<br>Radiation Protection Services<br>BC Centre for Disease Control<br>655 - 12th Avenue West<br>Vancouver BC V5Z 4R4<br>Tel: (604) 660-6630<br>Fax: (604) 660-6628 |
| **Yukon**<br>Workers' Compensation Health & Safety<br>401 Strickland St.<br>Whitehorse, YT Y1A 5N8<br>Tel: (867) 667-5376<br>Fax: (867) 393-6279 |

**Table 11.1** Canadian Provincial/Territorial/Federal Radiation Protection Contacts (Non-medical X-rays) (continued)

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| **Northwest Territories**<br>Workers' Safety & Compensation Commission<br>Northwest Territories and Nunavut<br>PO Box 8888<br>Yellowknife, NT X1A 2R3<br>Tel: (867) 669-4407 or 1-800-661-0792<br>Fax: (867) 873-0262 |
| **Federal**<br>Health Canada<br>H.P. (Harri) Maharaj<br>Physicist & Head,<br>Nonmedical X-Rays, CCRPB<br>Health Canada<br>775 Brookfield Rd<br>Postal Locator 6301A<br>Ottawa, ON K1A 1C1<br>Tel: (613) 954-0318<br>Fax: (613) 941-1734<br>Email: H_P_Maharaj@hc-sc.gc.ca |
| **Department of National Defence**<br>Director General Nuclear Safety<br>Rm 1702 Standard Life Building<br>280 Slater Street<br>Ottawa, ON K1A 0K2<br>Tel: (613) 995-8253<br>Fax: (613) 992-5537 |